AIGC-Empowered Smart Library Development: Foundations, Features, Scenarios, and Strategies (Postprint)

Authors: Hu Anqi

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Abstract

The emergence and development of Artificial Intelligence Generated Content (AIGC) will facilitate the creation of a new service paradigm for libraries, transforming them from traditional services to knowledge services and generative content services. Based on exploring the historical evolution of library content generation models, this article focuses on elaborating the technical foundations and intrinsic characteristics of AIGC empowering smart library construction, as well as the application scenarios for the integrated development of AIGC and smart libraries. Finally, it proposes development strategies such as improving the construction of foundational corpora, training high-quality large language models, enhancing the digital literacy of relevant personnel, and upgrading smart library infrastructure, to assist smart libraries in creating rich service application scenarios and meeting users' diverse and personalized needs.

Full Text

Preamble

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Title: Empowering Smart Library Construction: Basis, Characteristics, Scenarios, and Strategies

Author: Hu Anqi
Affiliation: Library of Suzhou University of Science and Technology, Suzhou

Abstract: The emergence and development of Artificial Intelligence Generated Content (AIGC) will facilitate the creation of entirely new library service formats, enabling libraries to transform from traditional services to knowledge

services and generative content services. Based on an exploration of the historical evolution of library content generation models, this article focuses on elaborating the technical foundation and intrinsic characteristics of AIGC empowering smart library construction, as well as the application scenarios for the integrated development of AIGC and smart libraries. Finally, it proposes development strategies including improving basic corpus construction, training high-quality large-scale language models, enhancing the digital literacy of relevant personnel, and upgrading smart library infrastructure, thereby assisting smart libraries in creating rich service application scenarios that meet users' diverse and personalized needs.

Keywords: AIGC; Smart library; Smart services; Application scenario; Metaverse
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1. Historical Evolution of Library Content Production Models

Modern libraries are undergoing a transformation from digital libraries to smart libraries, and the emergence and optimization of artificial intelligence technology have accelerated this process while also driving a fundamental shift in library content production models from "PGC+UGC" to "PGC+UGC+AIGC."

The Professional Generated Content (PGC) model dominated the early stages of digital library construction. During this period, the internet was static with classic catalog-based classification as its primary organization method [3]. Content creation and publishing rights remained primarily in the hands of professionals who relied on traditional input devices such as mice and keyboards to produce content. Users could only browse official library webpages without participating in the content production process. While this model produced highly professional content, its production scale was limited, and content quality was inconsistent. As content production volume increased, costs rose correspondingly [4].

The User Generated Content (UGC) model marked the transitional period from digital libraries to smart libraries. With the rise of mobile internet and social media platforms, the authority to generate and publish content shifted from experts to users. Users became the backbone of content production, creating and inputting content through voice commands, spatial gestures, and other methods. Content became more personalized and diversified, significantly enriching library resources. However, this model suffered from uneven content quality and originality issues, and the efficiency problems arising from its large-scale production urgently needed resolution.

The Artificial Intelligence Generated Content (AIGC) model represents the hallmark of the smart library era. AIGC utilizes artificial intelligence technology

to drive machine-created content, requiring special annotated data for training. In 2014, the emergence of Generative Adversarial Networks (GAN) enabled the generation of various modal content [5]. In 2022, OpenAI released ChatGPT, a large-scale model that, with support from massive computing power and strong algorithms, can engage in multi-turn conversations and meet users' diverse information needs through self-learning based on strong human feedback [6]. AIGC-produced content exhibits large-scale characteristics while maintaining quality and update frequency. It offers advantages of low unit cost and diminishing marginal costs, enabling continuous innovation and iterative model updates in smart library content.

2. Technical Foundation for AIGC Empowering Smart Library Construction

The application of AIGC in smart libraries relies on underlying support technologies including computer vision, natural language processing, and multimodal large models.

2.1 Computer Vision Technology Supporting Smart Library Digital Twins

Smart library digital twins refer to the digital replication of physical libraries, mapping real libraries to virtual ones. This process primarily utilizes intelligent enhancement and intelligent translation technologies in computer vision. Intelligent enhancement technology can eliminate issues such as data missing or damage during data content collection, transforming low-quality original data into high-quality digital content. Compared to intelligent enhancement, intelligent translation technology is more crucial for understanding and converting between different modal digital contents. It can synthesize subtitles from voice information, convert text content to speech, or even transform given images and videos into text, audio, and other modalities [8].

2.2 Natural Language Processing Technology Supporting Smart Library Content Editing

Smart library content editing aims to edit the virtual world to directly impact the physical world through real-time feedback and interaction. This requires natural language processing technologies including semantic understanding and attribute control. Early semantic understanding technologies could not handle semantic entanglement problems, but with advances in natural language processing, disentangled semantic learning technologies based on generative models have emerged. These technologies achieve deeper understanding of data content by learning changes in different semantic components. Building upon this foundation, intelligent attribute control technology can directly modify original digital content according to user-specified attributes, enabling tasks such as intelligent image editing and intelligent audio mixing, thereby improving smart

library digital content creation efficiency.

2.3 Multimodal Large Model Technology Supporting Smart Library Content Creation

Smart library content creation can be divided into imitation-based creation and concept-based creation. Imitation-based creation involves AI models observing human works, learning their external and internal features, and then creating imitative works. Concept-based creation goes beyond simple observation and imitation of specific work types, instead focusing on learning abstract concepts from massive data and creating novel works through concept combination. This requires algorithmic models to understand multimodal data and find correspondences between different modal data, as well as achieve mutual transformation and generation across modalities.

Recent popular models like ChatGPT have demonstrated immense value in content creation. Under AIGC empowerment, smart libraries can not only produce large-scale text, images, videos, and other two-dimensional content but also generate three-dimensional objects, scenes, and digital humans. When combined with virtual reality technology, users can experience various cultural activities in virtual venues, touch three-dimensional books with their hands, and engage in real-time interaction with avatars of various users. When users' visual, auditory, tactile, and even gustatory senses intertwine, user experience will be fundamentally transformed.

3. Intrinsic Characteristics of AIGC Empowering Smart Library Construction

Under AIGC empowerment, smart libraries exhibit intrinsic characteristics including upgraded user experience, high content production efficiency, and enhanced bidirectional real-time interaction.

3.1 Personalized Features

From the perspective of AI practice achievements, there are many interactive products, but most are semantically predefined and assist users based on their habitual behaviors without fundamentally reshaping the user interaction ecosystem. Content-generating products like ChatGPT, however, can learn and understand human language, engage in natural multi-turn conversations with users, and reshape the ecological structure of user interaction behavior [13]. This capability can understand users' actual knowledge needs based on their historical dialogue information and current learning content, providing personalized learning support [9-10]. It can also identify users' misunderstandings of certain content through multi-turn dialogue and provide personalized service recommendations.

3.2 Enhanced Bidirectional Real-Time Interaction

AIGC can question users' problems, provide multiple solutions, and continuously optimize models through multi-round human-computer interaction. When smart libraries introduce AIGC, the immediacy and efficiency of user-machine interaction will significantly improve, and the interaction mode between users and the library environment will undergo major transformation. AIGC can also combine with virtual reality, 5G/6G, blockchain, and other technologies to extend smart libraries into the metaverse space, becoming an important cornerstone for building library virtual worlds [14].

3.3 High Content Production Efficiency

AIGC can generate large amounts of digital content in a short time. With the continuous optimization of multimodal large models, marginal costs approach zero as production scale expands. The human-machine collaborative production model under AIGC empowerment can release staff time and energy, allowing them to focus on deep innovation in service forms and content. AIGC also has scale diminishing advantages, where unit content production costs decrease as content volume increases, promoting spiral development of the content ecosystem.

4. Application Scenarios of AIGC Empowering Smart Library Construction

4.1 Smart Production System: Diversified Production

The smart production system in smart libraries includes two major components: digital twins of existing collection resources and native digital resource production. The first involves digitally replicating collection resources to achieve perpetual preservation of physical collections in virtual space. The second relies on multimodal general large models, strong computing power, and massive training data to produce native digital resources. In this system, AIGC can effectively identify user voice and engage in natural language communication with users. Libraries can use this to build smart production systems that continuously innovate content forms.

4.2 Smart Retrieval System: Generative Retrieval

In digital library information retrieval, users typically need to repeatedly test and revise search term combinations to find needed answers, requiring certain retrieval skills and knowledge. Most users suffer from low retrieval efficiency. Smart libraries can leverage AIGC to create intelligent retrieval systems supported by natural language processing and data mining technologies [17]. Users can input multimodal natural language queries through text, voice, images, or video. The system first converts these queries into specific knowledge representations, accurately understands user intent through semantic analysis, quickly

searches for the most relevant information, and outputs intelligent answers in visual form.

4.3 Smart Dissemination System: Precision Communication

Digital library information dissemination primarily relies on librarians, but this model suffers from uncontrollable service time, content, and quality [19]. With the popularization of AI technology, smart libraries can develop various robots to undertake information dissemination tasks. For example, Tsinghua University Library developed a machine-readable cataloging language-based chatbot, while Shanghai Jiao Tong University Library developed a computer graphics-based chatbot. However, these robots currently cannot handle complex user needs. By effectively combining AIGC technology with robotics, libraries can develop intelligent chatbots better suited for specific service scenarios, achieving precise service reach to users with similar needs.

4.4 Smart Assessment System: Personalized Evaluation

AIGC can assist smart libraries in creating intelligent learning assessment systems [22]. Before learning begins, AI systems can generate visual analysis reports of users' existing knowledge structures to help them select appropriate learning paths. During learning, the system continuously collects user data including expressions, psychological changes, and physiological reactions, using big data analysis, association rule analysis, regression analysis, and clustering analysis [23] to form intelligent assessment reports. After learning, the system visually displays users' cognitive learning maps throughout the process. With human feedback reinforcement learning mechanisms, the system can even analyze users' reactions to assessment results, reshaping smart library evaluation models toward intelligent and smart development.

5. Development Strategies for AIGC Empowering Smart Library Construction

Faced with diversified production, personalized evaluation, and other service scenarios under the new operational logic, smart libraries must employ strategies including improving basic corpus construction, training high-quality large language models, enhancing digital literacy of relevant personnel, and upgrading smart library infrastructure to propel development to new stages.

5.1 Content Production Level: Improving Basic Corpus Construction

The key to AIGC technology application lies in massive multi-source, multimodal data. Smart libraries, as data resource aggregation centers, possess not only static literature data like books and patents but also dynamic data captured by various sensors, including library environmental status data and user behavior data [16]. However, data annotation is time-consuming, data diversity is

insufficient, and data acquisition and usage face privacy protection challenges. Synthetic data technology can help libraries address these issues. Generated through computer simulation technology or algorithms, synthetic data can serve as a substitute for real-world data to train models, improving data quality, increasing diversity, and avoiding privacy leakage [25]. Future synthetic data models should be incorporated into smart library basic corpus construction to promote sustainable development.

5.2 Content Retrieval Level: Training High-Quality Large Language Models

Training high-quality large language models using massive literature data is key to embedding AI models into smart library retrieval services. Large language model training and learning are core to text generation, and these models possess easy scalability and can utilize massive unlabeled text for pre-training. Smart libraries can build large-scale language models based on extensive literature data, user behavior data, and environmental data, enabling them to play value in keyword generation, intelligent question-answering, and text similarity calculation, thereby reshaping smart library information retrieval paradigms.

5.3 Content Dissemination Level: Enhancing Digital Literacy of Relevant Personnel

Improving content dissemination efficiency requires not only intelligent machines but also librarians and users with high digital literacy. On one hand, AIGC technology has high entry barriers, and few library staff have AI professional backgrounds. On the other hand, deep integration with smart libraries will raise issues including technical risks, privacy protection awareness, and ability to identify false information. Libraries should cultivate composite talents adapted to various scenario applications through regular training and institutional arrangements, and jointly develop suitable user digital literacy evaluation indicator systems with relevant departments to continuously optimize digital literacy improvement paths through evaluation and feedback.

5.4 Content Assessment Level: Upgrading Smart Library Infrastructure

Infrastructure is the carrier for collecting, transmitting, storing, and utilizing data, and serves as supporting power for smart library development. Upgrading library infrastructure is fundamental to building smart assessment systems. AIGC applications in smart libraries demand high computing power—for instance, GPT-3.5 model training required massive computing resources that most libraries cannot independently afford. Libraries can leverage enterprise facilities and national projects to improve computing power, rely on cloud servers and API calls to build infrastructure systems, and invest in intelligent wearable devices. The University of Rhode Island Library has introduced wearable technology, allowing users to read freely while the library collects multimodal data

from these devices for comprehensive analysis and assessment using AI models, which is crucial for building powerful smart assessment systems.

6. Conclusion

AIGC's technological advantages in content creativity, cross-modal fusion, and cognitive interaction will further drive the transformation of traditional library service models, gradually realizing a smart service model of "AIGC+". Application scenarios in smart libraries will continue expanding, ultimately achieving deep integration with blockchain, virtual reality, and other technologies to construct a new service ecosystem blending virtual and real elements [26].

However, challenges remain. Issues such as intellectual property attribution and determination, false information and errors, user privacy leakage, and algorithmic discrimination are not yet maturely resolved. Smart libraries must adopt strategic development frameworks, promote overall development through single-point local construction, and equip professional AIGC technical teams. By providing advanced professional learning and regular training, smart libraries can address these challenges while harnessing AIGC's potential to create rich service scenarios that meet users' diverse and personalized needs.

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