International Cartographic Association
Association Cartographique Internationale

Exploration of Atlas Multi-Level Knowledge Service Platform Development and Application

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Abstract:

As a knowledge product of scientific and cultural resources, the atlas encompasses multi-source, multi-scale, multi-temporal, multi-type, and multi-disciplinary knowledge, information, and data. Based on the construction and application practice of the information sharing service platform of "China Thematic Atlas Resource Network", this paper proposes the knowledge service needs of atlas resources in the era of informatization and big data, and fully integrates national strategic and new technologies of the times, builds a multi-level knowledge service system framework including content system, expression system, technology system, and application system, further explores a multi-level knowledge service model for field applications of atlases.

Keywords: Atlas; Design System; Knowledge Services

1. Introduction

Atlases, as significant scientific and cultural products of surveying, mapping, and geographic information, embody the characteristics of intellectual products, including ideological depth, scientific rigor, contemporaneity, and practicality. These are regarded as "encyclopedias for constructing a nonlinear and complex geographical world"(Wang, 2021) (Fang, 2014), crucial in supporting national strategies and meeting the public's demand for scientific and cultural knowledge dissemination. The compilation of atlases is not merely an integration of multi-sectoral, multi-scale, multi-temporal, and multi-type geospatial data but also a process of scientific thinking, summarization, and comprehensive integration of scientific and cultural information.It is not only a complex systemic project but a scientific, artistic, and knowledge endeavor characterized by systematicness, professionalism, integration, and sharing(Qi., Chi., et al., 2001). As a product of knowledge and innovation, atlases represent the convergence of contemporary technological development and applied practices.

This paper explores the compilation design systems and service models of atlases oriented toward knowledge services based on the construction in practices of the "China Thematic Atlas Resource Website" information-sharing service platform, then presents several reflections for discussion and invites further exploration from the academic and professional community.

2. The Knowledge Characteristics and Changes of the Functions of Atlases

An atlas is a collection of maps characterized by a unified overall design, a complete conceptual framework, a systematic, logical structure, organically interconnected internal components, advanced technical methods, and modern artistic styles (Wang, 2022). The design of atlas compilation oriented toward knowledge services involves the technical production processes from the cartographer's perspective—such as data collection, data processing, map design, cartographic compilation, platemaking, printing, publication review, and the consideration of knowledge services. This additional consideration about knowledge services requires designing corresponding application service models based on varying user needs, content characteristics, and product functionalities. It further necessitates the construction of an overall framework for atlas compilation design, including content systems, expression systems, technical systems, and functional systems. The compilation of the atlas includes the technical product design system and the atlas knowledge service system. Unlike the atlas design system, the knowledge service system focuses more on expressing the atlas theme's characteristics, evolution, interaction, and regional change characteristics in its elements, patterns, processes, and functions. To better uncover the humanistic value of maps and enhance the role of cartography in societal development, it is necessary for cartographers to temporarily divert attention from the technical aspects of cartography and focus more on the content that maps can convey—the world composed of nature and humanity (Gao., Cao, 2021). The differences in focus between the two perspectives are summarized in Table 1.

Advances in Cartography and GIScience of the International Cartographic Association, 5, 13, 2025.
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	Traditional Atlas	Atlas' Knowledge Service
Element and Structure	The traditional atlases' element emphasizes the organization of a publication framework that highlights the structural components of the content, such as the overall structure of the atlas, the division of map groups, the relationship between main maps and supplementary maps, and the integration of text and charts.	The domain knowledge-oriented system emphasizes classifying content attributes and their spatial relationships, such as those about the natural environment and socioeconomic factors. It reflects the logical relationships between geographic phenomena, patterns, and evolutionary processes.
Expression Methods	The expression of atlas content revolves around geographical thematic elements, combining text, charts, and maps. It focuses on the use of cartographic language and artistic representation, with interrelated components that may or may not be directly connected. This includes foundational map elements, map symbols, hierarchical relationships formed by points, lines, areas, volumes, and spatiotemporal relationships.	Atlas' Knowledge Service system is centered on the domain knowledge ontology, focusing on the elements, patterns, processes, and their interactions. Examples include urban agglomerations, disaster-bearing bodies, and geological structural units. It emphasizes the representation of geographic complexes, single-element and multi-element patterns, and the interconnections of spatial, temporal, and attribute dimensions. It also addresses the differentiation and connections among elements, patterns, processes, and the nesting and reorganization of different classifications.
Technical System	The atlas production process involves techniques for visualizing, presenting, and interacting with data and knowledge. Standard methods include chart creation, map drawing, animated charting, and interactive interface design. Additionally, it encompasses cartographic representation methods, mathematical foundations in data processing, production systems, publication systems, and printing technologies.	Knowledge prioritizes data analysis techniques, including data cleaning, transformation, integration, and analysis. These processes leverage advanced data mining, machine learning, and statistical and spatial analysis methods. They enable the extraction of helpful information and knowledge from large datasets, such as risk assessments, process simulations, and spatiotemporal evolution.
Application and Function	The compilation, publication, and distribution of atlases, including information retrieval, sharing, and dissemination of electronic atlas products, are integral parts of the system. Typical services include the publication of atlases and their limited circulation within specialized professional domains. The advantage of printed atlases lies in their offline accessibility, portability, and suitability for outdoor activities or travel. However, their dissemination range and influence are relatively limited.	Atlas' Knowledge Service focuses on disseminating, sharing, and publishing knowledge through platforms like online publishing, social media, open access (OA), and information retrieval. It also encompasses technologies for ensuring data and knowledge security, privacy protection, and copyright management. Common techniques include data encryption, access control, and digital rights management (DRM). These technologies facilitate the secure and compliant sharing of data and knowledge while expanding their dissemination scope and impact.

Table 1. Atlas Changes in Design and Development

3. Development of Multi-level Atlas Information Sharing Platform

In 2012, the author established the "China Thematic Atlas Resource Network" (www.zhuantitu.com), an information-sharing platform dedicated to the collection and dissemination of thematic atlas resources. Since its launch over a decade ago, the platform has supported education and research for many user groups, including universities and research institutions, by providing access to atlas catalogs, static maps, dynamic maps, and interactive maps. The platform has published static electronic atlases such as the *Atlas of Sustainable Development of Resources Environment and Development of Jiangsu Province*, the *Atlas of Gender Equality and Women's Development in China*, and the *Atlas of Arctic and Antarctic*. Additionally, it also has developed dynamic electronic atlas systems of the *Comprehensive Natural and Desertification Atlas of Tibet* and interactive online atlas system named *Thematic Disaster Information Atlas Publishing System*.

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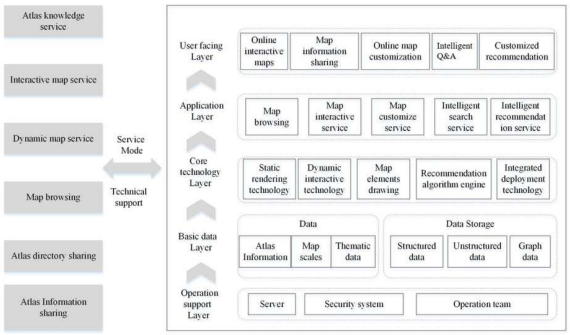

Figure 2. Multi-Level Knowledge Service Framework

3.1 Innovative Techniques in Platform Development

(1) A Muti-Dimensional Classification System for Atlas Resources:

A hierarchical structure integrating "map library–atlas–map sheet–map element" was combined with a muti-dimensional attribute model consisting of "thematic map content–spatial scale–data type–publication information." This structure addresses the standardization challenge of multi-source, laying a theoretical foundation for cross-disciplinary data integration.

(2) A Cross-Media Architecture Combining Map Library and Service Platform:

An integrated "atlas resource library + intelligent service platform" model was independently developed to attain gradually multimodal combination between print and digital map products. This cross-media service platform supports coordinated services across both web and mobile interfaces, enabling broader access and interactive use of thematic atlas resources.

(3) An Intelligent Knowledge Service Model for Thematic Atlases:

An embedded map knowledge engine was constructed, integrating a base map template library and thematic symbol expression library to support structured and systematic atlas content management. Through the development of a map element classification system, metadata model, semantic tagging scheme, and knowledge graph, the system enables semantic association and intelligent orchestration of atlas content.

3.2 Multi-Level Knowledge Sharing of Atlas Resource

Each atlas encompasses a specific theme and a structurally independent and complete set of content. By employing a knowledge deconstruction approach, the content of atlases can be standardized, systematized, and structured. This process establishes connections among different atlases, map groups, map sheets, and themes.

3.2.1 Static atlas sharing:

Static atlas publication is a third-level restricted authorization sharing model, characterized by the same data format as paper atlases and a page-turning reading experience. Through an integrated electronic atlas publishing system, it realizes functions such as directory indexing, image browsing, voice-guided reading, and high-definition zooming, facilitating quick jumps and selective access between different chapters, and enhancing the overview and visualization of electronic atlas reading.

Figure 3. E-Atlas

3.2.2 Dynamic Atlas Sharing:

Dynamic atlas publication represents a fourth-level restricted authorization sharing model, characterized by mouse-click expansion and dynamic attribute prompting that highlight the reading features of electronic media. It deconstructs map elements and layers, optimizes online map expression and reading methods through an online dynamic atlas system, and achieves dynamic visual expression of cartographic symbols. Users can conveniently view the display effects of different atlases through online browsing, enhancing the reading experience.

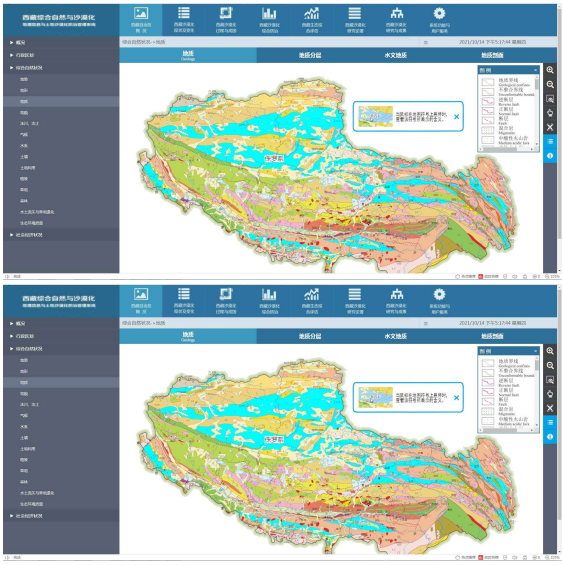

Figure 4. Dynamic Atlas Sharing System Interface

3.2.3 Interactive Atlas Sharing:

Interactive atlas publication represents a fifth-level restricted authorization sharing model, characterized by database-driven online cartography and interactive modes. Through the establishment of a thematic atlas online publishing system integrating data, software, and models, it enables the online map publication of various thematic information data. The system can select socio-economic statistical information and natural resource/environmental information data related to space. By employing data visualization and spatialization technologies such as customized geographic base map publishing data processing, dynamic thematic statistical charts, dynamic thematic map cartography, and geostatistical models, it meets the personalized needs for map customization.

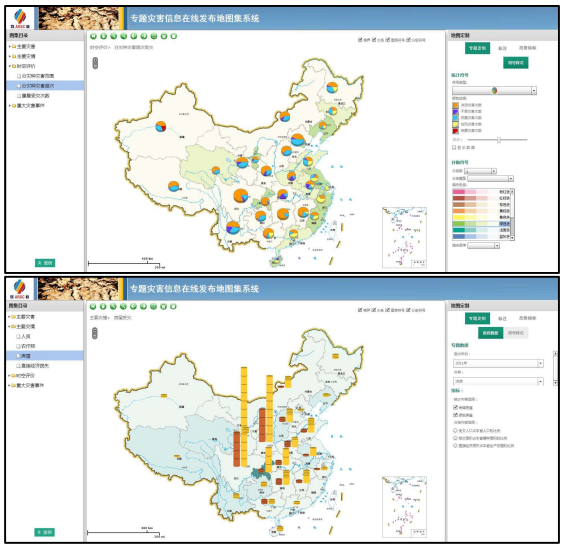

Figure 5. Interactive Atlas Sharing System Details

3.2.4 Online Atlas System and A Case:

The Online Atlas system is a system that includes the functionality and advantages of the three sharing modes above and applies these strong points. The Urbanization and Green Development Online Electronic Map System of Qinghai-Tibet Plateau was developed based on the Urbanization and Green Development Atlas of Qinghai–Tibet Plateau. It shows a comprehensive application of WebGIS, JavaScript, Python, SVG element laying, and SQL to present the thematic elements of the atlas through an integrated digital platform. The system supports both PC and mobile access, providing full browsing functionality and rich interactive features (Figure 6).

The platform is built upon a framework that integrates static and dynamic map data and offers both foundational and customized functions. Basic functions include zooming, paging, and keyword search; customized functions include interactive legends, time-series animations, and route playback tailored to map content. These interactive features enrich map expressions and enhance user experience while revealing the latent value of map resources.

Overall, the platform combines a rendering engine, search engine, vector map services, and map tools with innovative design, thereby empowering the scientific and artistic expression of the atlas. Based on customized content requirements, data from finalized atlas maps were extracted and processed to support dynamic interactivity. These Core operations are supported by modular content layers (e.g., base maps, thematic layers, legends, tables, and auxiliary graphics), which can be independently processed and dynamically assembled. This layered segmentation and reprocessing involved the use of various software tools and scripting methods to implement features such as symbol interactivity, legend linking, and text-based search within the Electronic Atlas System for Green Urbanization Development on the Qinghai–Tibet Plateau. The approach establishes a practical model from data classification and processing to an interactive online map application.

Figure 6. One Web Page of Urbanization and Green Development Online Electronic Map System of Qinghai-Tibet Plateau

4. Conclusion and Discussion

In the age of artificial intelligence, data elements have become a key driving force for high-quality development. Expanding the breadth and depth of data application scenarios, promoting the orderly openness and sharing of scientific data, enhancing the reuse value of scientific data, and fostering cross-institutional, cross-disciplinary, and cross-domain collaborative innovation are all critical objectives. Consequently, contemporary atlas design and compilation should move beyond the traditional goal of merely producing a single atlas. Instead, atlas compilers

should pay attention to the layered integration and management of atlas content resources, strengthening knowledge mining, association, management, and application. They are supported to fully consider the advancements in modern technology and the promotion and application of results, aiming to uncover the more scientifically applicable, visually intuitive, and flexibly functional knowledge value and application potential of atlases.

Building a multi-level, multi-interface, and intelligent open platform for atlas information sharing and knowledge services, based on the foundation of the "China Thematic Atlas Resource Network," is an exploration toward creating a collaborative and shared platform for the integration and application of atlas resources. This platform was developed to meet users' needs for intelligent retrieval, flexible customization, diversified presentation, and personalized application of atlas knowledge. At its core, it leverages digitization, knowledge-based organization, customization, and intelligent solutions to provide more convenient, efficient, and intelligent atlas resource knowledge services for education and research.

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