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Exploration of Digital Preservation for the Historical Architectural Complex of Wudang Lamasery in Inner Mongolia

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Abstract: Wudang Lamasery is the largest surviving temple of the Gelug sect of Tibetan Buddhism in Inner Mongolia, with important historical, cultural, and academic research value. As an important dissemination of Tibetan Buddhist culture in Inner, its architectural complex not only shows a unique spatial layout of religious beliefs and ceremonial activities but also contains rich historical contexts of art, technology, and cultural exchanges. This paper systematically researches the historical evolution and layout characteristics of the Wudang Lamasery architectural complex, combines digital technology, and puts forward innovative protection ideas and frameworks for the protection and utilization of the existing Wudang Lamasery historical buildings, striving to provide scientific and effective new paths for the protection of the Wudang Lamasery historical buildings.

Keywords: Wudang Lamasery; digital technology; historic building preservation; Grupa temple; Virtual reality (VR); virtual museum

0. Introduction

Wudang Lamasery is a National Key Cultural Relics Protection Unit, located in the Daqing Mountains in the hinterland of Inner Mongolia's Yinshan Mountains. As one of the most well-preserved Tibetan Buddhist temples in the western part of Inner Mongolia, it is one of the three major Gelugpa temples in the extra-Tibetan region [1], with a deep history and outstanding cultural value. However, with the development of social informatization, the traditional way of cultural relics protection and management is difficult to fully meet the high-standard requirements for cultural heritage protection in the new era. At present, most of the digital research on Wudang Lamasery's historical buildings focuses on the field of surveying and mapping technology, especially in the three-dimensional scanning and building structure modeling, among other aspects. However, the research on the systematic arrangement of architectural information, the construction and application of digital databases, and other fields is relatively lagging behind, lacking multi-dimensional and systematic data support. This status quo limits the depth of protection and research on the historical buildings of Wudang Lamasery and fails to give full play to the potential of digitization technology in cultural relics protection, restoration, and dissemination.

The development of a digital database for Wudang Lamasery's historical buildings holds significant practical and academic value. The establishment of a comprehensive digital database serves multiple purposes:

1. It provides detailed data support for architectural conservation and restoration, enabling the optimization of restoration plans and improvement of restoration accuracy [2].
2. It offers systematic research resources for academic scholars and cultural heritage administrators, facilitating in-depth analysis of architectural styles, craftsmanship characteristics, and cultural significance.
3. Through the application of virtual reality (VR), augmented reality (AR), and other advanced technologies, it presents Wudang Lamasery's architectural heritage and cultural context to the public in more engaging and accessible formats, thereby enhancing social awareness and cultural influence.

The digital protection of Wudang Lamasery is not only the inevitable requirement of technical development but also the historical mission of inheriting the diversified culture of the Chinese nation. Enabling the protection and dissemination of historical buildings through advanced technology will not only continue the cultural vitality of Wudang Lamasery but also promote more people to deeply understand and feel the unique charm of this cultural treasure, setting a new benchmark for the cultural relics protection cause

1. Research on Wudang Lamasery Architectural Complex in Inner Mongolia

1.1. History

Wudang Lamasery, situated in Baotou City of the Inner Mongolia Autonomous Region, was initially constructed during the reign of Emperor Kangxi (1662-1722) of the Qing Dynasty. The temple underwent significant restoration in 1749, specifically in the fourteenth year of the Qianlong era, at which time it was officially bestowed with the appellation 'Guangjue Temple'. Subsequently, the temple was expanded multiple times during the Jiaqing, Daoguang, and Guangxu periods, gradually evolving into its current scale. The temple's original name in Tibetan is 'Badagar Zhao,' meaning 'White Lotus' [3], symbolizing purity and holiness. Due to its location on the hillside of Wudang Gully Aobao Mountain, it was named 'Wudang Lamasery' [4] (see Figure 1).

Currently, Wudang Lamasery consists of over 2,500 buildings, including halls, scripture halls, and monk quarters, covering an area of more than 300 acres. These buildings are distributed along a hillside approximately 1.5 kilometers long, with a flexible and ingenious layout that fully reflects the harmonious coexistence with the natural environment. The temple's spatial organization centers around the main scripture hall, surrounded by various learning halls and functional buildings. The formation of Wudang Lamasery has been deeply influenced by both the terrain and Buddhist rituals. On one hand, the planning and construction of the complex fully adapt to the terrain, with the buildings following the mountain's contours to ensure structural stability and a sense of layering. On the other hand, the layout, design, and structure of Wudang Lamasery significantly reflect the characteristics of Tibetan Buddhist architecture, influenced by the architectural style of Tibet [5]. For example, the floor plan and decorative details of the main buildings show the inheritance and reinvention of traditional Tibetan religious architecture, making it a model of the fusion between grassland and plateau cultures.

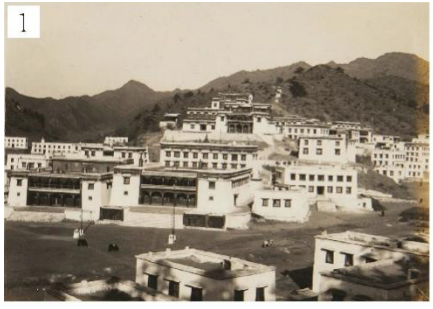

Figure 1. Historical Photos of the Wudang Lamasery Architectural Complex in Inner Mongolia: (1) Aerial View (2) Scripture Hall (3) Monk Quarters

Additionally, Wudang Lamasery is not only an important site for religious activities but also a symbol of cultural promotion and ethnic exchange. Its architectural features, historical development, and cultural value have made it one of the most representative Tibetan Buddhist temples in northern China, attracting numerous scholars and visitors for both sightseeing and research.

1.2. Layout Features of the Wudang Lamasery Architectural Complex

The overall layout of Wudang Lamasery is deeply influenced by the Tibetan Buddhist cosmological view of the Dzogchen tradition, skillfully integrating religious concepts into the architectural planning. The entire temple is centered around the Suguqin Hall, with other temples distributed around it, mimicking the structure of the Buddhist cosmic realm. According to Buddhist cosmology, this layout symbolizes the order and harmony of the universe, reflecting the spiritual core of 'center and surrounding' in Buddhist belief.

The temple's overall structure is centered on the concepts of 'One Tomb,' 'Three Mansions,' and 'Six Halls,' expanding in layers to form an architectural system that is both solemn and sacred, yet harmonious and unified [6].

The 'One Tomb' refers to the Subugai Tomb, one of the most religiously significant buildings in Wudang Lamasery. The Subugai Tomb is not only an important site for the teachings and practice of living Buddhas but also the location where the stupas of deceased living Buddhas are placed. The ashes of the living Buddhas are enshrined here, symbolizing the continuation and transmission of wisdom and practice, further emphasizing the central position of this building within the temple.

The 'Three Mansions' refer to the Ganjur Mansion, Zhangjia Mansion, and Dongkuoer Mansion, collectively known as the Living Buddha Mansions. These three residences served as places where successive living Buddhas resided and handled religious affairs, as well as important bases for the spread of Buddhist culture and the interpretation of teachings. The Ganjur Mansion is associated with the Buddhist scriptures 'Ganjur,' symbolizing the source of wisdom in Buddhist texts; the Zhangjia Mansion is closely related to the lineage of Zhangjia Living Buddhas, representing the continuity of Buddhist faith; and the Dongkuoer Mansion holds special significance in religious practice, offering spiritual guidance and ritual support for followers and monks.

The 'Six Halls' are an important component of the temple complex, including the Suguqin Hall, Queyila Hall, Dongkuoer Hall, Dangeshide Hall, Lami Ren Hall, and Ahui Hall [7]. The Suguqin Hall is the center of the entire temple, serving the most core religious functions and hosting important Buddhist events and ceremonies. Queyila Hall and Dongkuoer Hall are primarily used for the study and recitation of Buddhist scriptures, serving as places for monks' practice and research. Dangeshide Hall and Lami Ren Hall focus on the enshrinement of Buddha statues and the worship of devotees, creating a solemn religious atmosphere. The Ahui Hall plays a supportive role in the daily practice of monks, helping with the daily operations and religious activities of the temple.

The layout of the 'One Tomb,' 'Three Mansions,' and 'Six Halls' at Wudang Lamasery not only reflects the spatial expression of religious concepts but also showcases its complex and orderly functional zoning. This unique planning form preserves the architectural characteristics of Tibetan Buddhist temples while integrating the natural and cultural features of the northern grassland region, making it a classic example of religious architectural spatial organization.

2. Significance of Building the Wudang Lamasery Historical Architectural Database

2.1. Preservation and Management of Wudang Lamasery Historical Architectural Information

The establishment of the digital platform for the Wudang Lamasery historical architectural complex in Inner Mongolia enables the high-precision digital modeling of existing buildings, allowing for the permanent

preservation of the complex's structure, details, and ornamentation [8]. This process not only provides detailed technical support for future restoration work but also effectively stores the original data of the buildings, offering strong support for cultural heritage protection. The platform's database integrates a wide range of information resources, including images, historical documents, design drawings, and more. Through powerful search functionality and a structured data storage mechanism, a comprehensive digital archive system has been formed, supporting researchers and the public in deeply exploring the architectural history, cultural value, and craftsmanship of Wudang Lamasery. Compared to traditional paper-based document management, this platform effectively avoids the issue of "information silos," enhancing data sharing and accessibility [9].

Moreover, the platform incorporates artificial intelligence (AI) technology to automatically categorize, summarize, and analyze building-related information [10]. This not only improves the efficiency and accuracy of data organization and retrieval, but also provides researchers with in-depth analytical capabilities. For example, AI can identify architectural changes over time by comparing literature and image data, and analyze the evolution of specific architectural techniques in different periods. In the future, the digital platform could even support immersive experiences, using virtual reality (VR) technology to recreate the original appearance and historical scenes of the architectural complex, providing innovative support for education, research, tourism, and other fields.

2.2. Contribution to the Restoration and Research of Wudang Lamasery Historical Architecture

The digital database of the Wudang Lamasery historical architectural complex provides comprehensive data support for research, preservation, and restoration efforts. First, by establishing the database, diverse information from different sources is integrated into a unified platform, encompassing historical documents, image materials, design drawings, and other content. This centralized management model significantly enhances researchers' efficiency in information retrieval and learning, making multidimensional exploration of the architecture more convenient.

Secondly, the digital database transcends the limitations of traditional paper-based or static materials, offering more technical possibilities for architectural research. For example, through 3D modeling technology, the database can accurately record the dimensions, colors, and texture features of different parts of the Wudang Lamasery historical buildings, generates realistic virtual models. This technology not only provides reliable and accurate data support for academic research but, with the help of virtual reality (VR) technology, also offers the public a new, immersive way to experience the spatial layout and atmosphere of the architecture, deepening their understanding of the building's cultural significance [11].

More importantly, digital technology introduces innovative methods for the preservation and restoration of Wudang Lamasery architecture. With the virtual models, restoration teams can simulate different restoration plans [12] and make direct comparisons to evaluate the feasibility and effectiveness of each option. This pre-simulation approach not only reduces trial-and-error costs during the restoration process but also ensures that the work is more scientific and precise. For instance, through multidimensional analysis of the virtual models, restoration teams can more accurately restore the original appearance of the architecture, preserving its cultural value and historical significance.

2.3. Establishing a Digital Museum

Leveraging modern computer technology, the creation of an engaging and interactive digital virtual museum [13] for Wudang Lamasery aligns with the current trend of digital cultural dissemination, making traditional culture more accessible and appealing to the public [14] (see Figure 2).

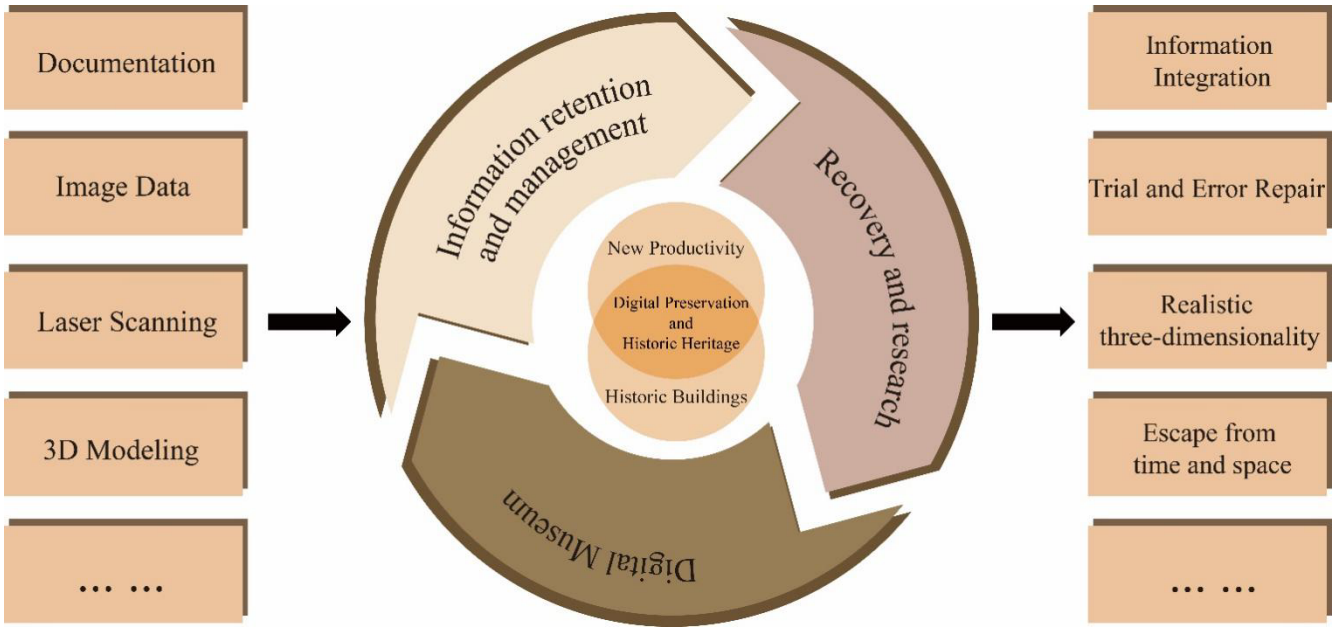

Figure 2. Significance of Building the Wudang Lamasery Historical Architectural Database

The Wudang Lamasery virtual museum breaks the constraints of time and space, allowing visitors to explore the architectural complex anytime and anywhere via the internet, experiencing its unique historical and cultural charm. The virtual museum not only showcases real-life photos, videos, text descriptions, and voice narrations of Wudang Lamasery, but also integrates various modern digital technologies, such as interactive visual design, animation effects, and immersive gaming scenarios [15]. These innovative methods not only enhance the visual appeal of the exhibits but also increase user engagement and interactivity, making the visiting experience more vivid and enjoyable.

Additionally, the virtual museum incorporates a range of practical features, fully catering to the diverse needs of visitors. For example, the platform provides services such as online ticket purchasing, reservation scheduling, and phone consultations, creating a one-stop integration of tourism services. With these functions, users can easily plan their offline visits while simultaneously deepening their understanding of the Wudang Lamasery architectural complex and its historical and cultural background online. Through this platform, the public can experience the artistic charm and cultural depth of Wudang Lamasery in a relaxed, enjoyable, and convenient manner, fostering the inheritance and dissemination of cultural heritage in the digital age.

3.The Main Framework and Content of the Wudang Lamasery Historic Architecture Computer Database

The first step in establishing the Wudang Lamasery digital database is the acquisition of architectural information, including archaeological materials, epic records, historical photographs, and on-site surveys The second step is to classify the collected information, including texts, drawings, etc [9] Following this, the database is created through data processing, calculation, and innovative data entry methods, with the required results being output The structure of the database can generally be divided into three levels: the foundational data layer, the program layer of the operating engine, and the application layer for data entry, queries, and other operations.

3.1. Data Layer

The construction of the Wudang Lamasery architectural database, requires comprehensive integration of textual information, technical drawings, and digital models to provide full support for research, preservation, and exhibition.

Firstly, the organization of textual information provides essential foundational data for a deeper understanding of the Wudang Lamasery architecture. In terms of metadata, internationally recognized cultural

heritage metadata standards, such as CIDOC-CRM or Dublin Core, are adopted, with defined fields including: building name, construction date, restoration records, functional changes, religious significance, and sources of literature (with precise citations to page numbers). The classification and coding system can refer to the *Chinese Ancient Architecture Classification Standard* (GB/T 51232-2016). In terms of digital text formatting, original documents should be scanned at a resolution of ≥600dpi and stored in TIFF format to support OCR text recognition. To ensure efficient data storage and management, MySQL or MongoDB databases are used, with connections to the timeline (TimelineJS) and geographic coordinates (GeoJSON) to build a structured database.

Secondly, the collection and organization of surveying and mapping technical drawings is a crucial part of the digitalization process for the Wudang Lamasery architectural complex. This data primarily includes the overall site plan of the Wudang Lamasery architectural complex, with detailed annotations of the surrounding environment and the relative positions and spatial relationships of the buildings within the complex. During data collection, the CGCS2000 national geodetic coordinate system should be used, with the 1985 national vertical datum as the elevation reference, ensuring accuracy with a horizontal error of ⩽5cm and a vertical error of ⩽3cm (using total stations or RTK GPS). Additionally, floor plans, elevation views, and typical section views of each individual building are required to comprehensively display the spatial layout and structural features of the buildings. To improve accuracy, laser scanning technology can be used during data collection, such as the Faro Focus S series scanners, ensuring that the point cloud density reaches ⩾10 points per square centimeter. Moreover, detailed drawings of structural nodes are essential for accurately recording the building' s details and craftsmanship, providing technical support for subsequent research and restoration efforts. When drafting the drawings, the scale for the floor plans, elevations, and sections can be set at 1:50, while the scale for detail drawings can range from 1:5 to 1:20. CAD files should be layered according to function (e.g., walls, beams, columns, decorations, etc.) and ensure that line types conform to the Architectural Drawing Standards (GB/T 50104-2010).

Finally, the creation of a digital model is a crucial step in the preservation and exhibition of the Wudang Lamasery architectural complex. Using modeling software such as SketchUp, Unity [16], and Revit, the Wudang Lamasery architectural complex is accurately recreated in a computer, generating a 3D digital model with true proportions and details. To ensure the accuracy and quality of the model, high-end equipment was used for data collection [17], including the Leica RTC360 ground laser scanner (accuracy ±1mm, scanning rate of 2 million points/second) and the DJI M300 RTK drone [18] (flight height 50m, ground resolution 1cm/pixel). In terms of model topology optimization, the polygon count was controlled to ensure that Level of Detail 0 (LOD0, low detail) maintains ≤500,000 polygons, while Level of Detail 3 (LOD3, high detail) contains ≤20 million polygons. The texture mapping resolution was set at 4096×4096 pixels, utilizing Physically Based Rendering (PBR) materials with metalness/roughness workflow. For software technology, modeling and BIM use Revit (following the Tibetan Buddhist Architecture BIM Standard for defining component libraries), and Rhino+Grasshopper is used for parametric generation of decorative patterns. Virtual presentation and interaction are achieved through Unity/Unreal Engine, which allows for model optimization (mesh compression + LOD level differentiation), supports WebGL real-time rendering, and utilizes 8K 360° panoramic images and HDR light baking techniques for panoramic navigation. In restoration simulation, ANSYS is used for structural analysis (load simulation accuracy ⩽5%), and 3ds Max is used for weathering and erosion visualization, employing time-based material degradation algorithms for precise restoration simulation. This model not only provides the foundational data for virtual display and interactive experiences but also plays a key role in the preservation and restoration process, enabling efficient simulation and comparison of different restoration plans. It offers essential support for the establishment of the Wudang Lamasery Digital Museum.

3.2. Program Layer

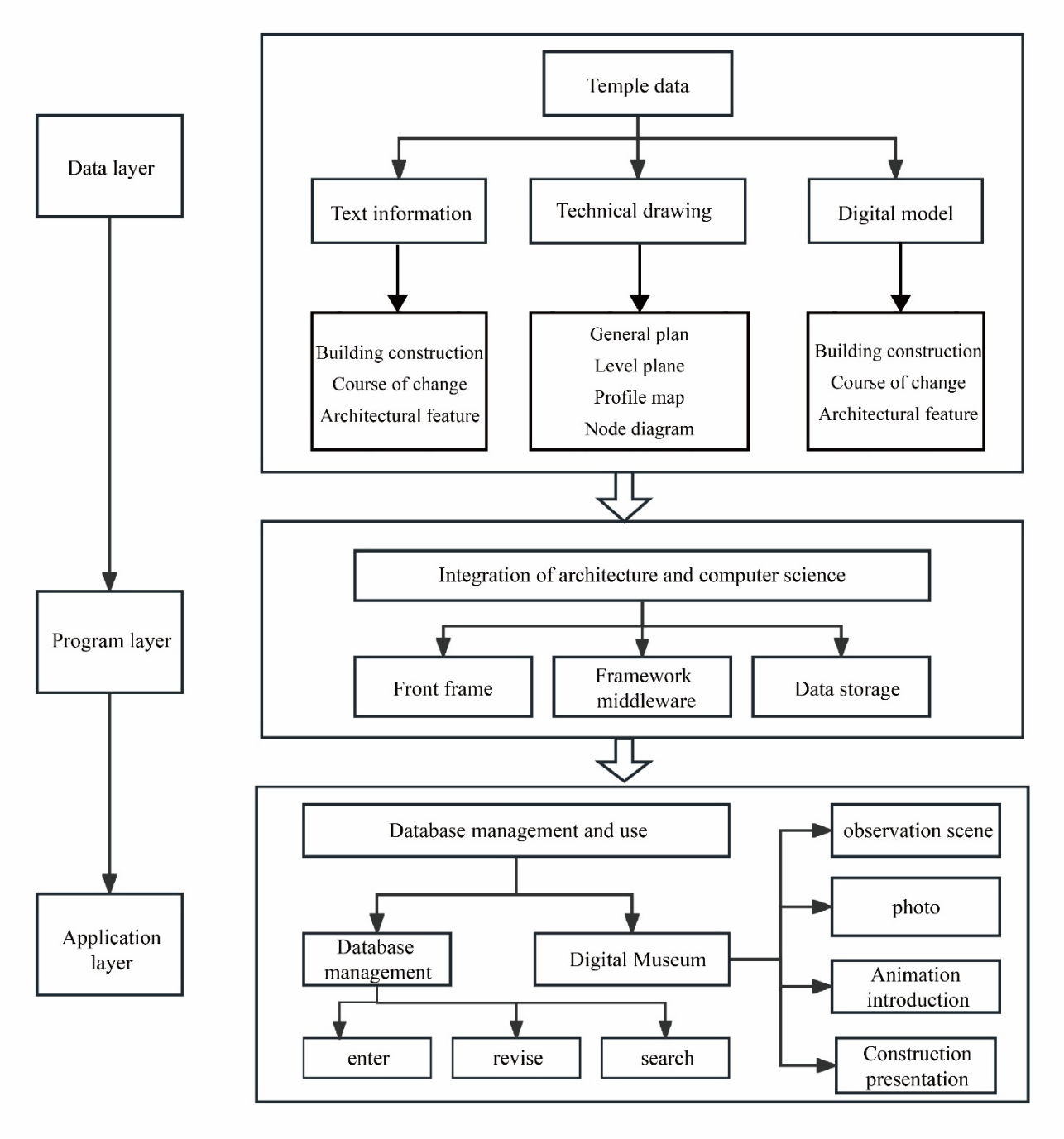

Figure 3. The Main Framework and Content of the Wudang Lamasery Database

The program layer is a critical technical component of the Wudang Lamasery digital database system, reflecting the deep integration with computer technologies. Its core function is to connect the user interface with the backend database, providing support for efficient data storage, processing, and interaction (see Figure 3).

First, the frontend framework, AngularJS, is one of the key technologies in the program layer [19]. As an application design framework and development platform, AngularJS is primarily used for developing the user interface in the database construction. The framework has core features such as modularity, automatic two-way data binding, and the MVVM (Model-View-ViewModel) architecture. These features make it particularly effective in building dynamic and responsive user interfaces, providing users with a friendly and smooth interaction experience [20].

Second, the database storage is implemented using MongoDB [21], which is written in C++. MongoDB is a distributed file storage database that supports the efficient storage and management of non-relational data. Its outstanding features include support for multiple query languages, flexible document storage formats, and powerful indexing capabilities. These characteristics make MongoDB excel in handling complex queries, supporting distributed storage, and dynamic scalability, making it especially suitable for the large-scale and diverse data management needs of the Wudang Lamasery architecture database [22].

Lastly, the program layer also includes middleware frameworks such as Express and Node.js [23], which are mainly used to connect the frontend application with the backend database. These middleware act as a bridge in the program layer, providing reliable support for the fast transmission and logical processing of data between different layers, while simplifying the development process and enhancing system stability and maintainability.

Through the integrated use of technologies such as AngularJS, MongoDB, Express, and Node.js, the program layer not only ensures the efficient operation of the database but also guarantees that users can quickly access, operate, and analyze data through an intuitive interface, providing strong technical support for the construction of the Wudang Lamasery digital database.

3.3. Application Layer

The application layer is the direct service interface of the Wudang Lamasery digital database, primarily responsible for the management and use of the database, including data entry, maintenance, and diversified information output. Through the application layer, the content in the database can be effectively utilized to meet the needs of both administrators and the public.

In terms of database management, the application layer enables the entry, correction, and maintenance of information [24]. For instance, multimedia data such as text, images, videos, animations, technical drawings, and 3D models within the database can be dynamically updated, ensuring the integrity and real-time accuracy of the content [25]. Additionally, the application layer supports the diversified output of information to meet the different needs of users.

In publicly accessible application scenarios, the application layer can be used to construct the Wudang Lamasery digital museum. By outputting dynamic 3D models, real-life photos, introduction animations, and architectural details and technical drawings, it provides visitors with a rich visual and interactive experience. For example, users can dynamically observe the 3D model of Wudang Lamasery on a virtual platform and explore the architectural space and details from various angles; high-resolution photos and animations allow them to grasp the historical background and cultural significance of the buildings [26].

Furthermore, the application layer supports various flexible search methods to help users quickly find the information they need. For example, users can search by building name, categorizing the Wudang Lamasery buildings into groups such as "One Tomb," "Three Mansions," and "Six Temples"; by building function, such as residential buildings, ceremonial buildings, or office buildings; or by parameters such as building grade and construction time. This multidimensional search approach greatly enhances the operability of the database and improves the user experience, making it easier for researchers and visitors to access accurate information.

Through comprehensive support from the application layer, the Wudang Lamasery digital database not only becomes an important tool for administrators but also provides the public with an intuitive and convenient cultural heritage experience platform, opening new avenues for the preservation and cultural dissemination of Wudang Lamasery's historic architecture.

4. Conclusion

The field of architecture has always placed great emphasis on the study of Tibetan Buddhist architecture, and, as the largest Tibetan Buddhist monastery in western Inner Mongolia Autonomous Region, Wudang Lamasery

holds an irreplaceable and significant position in this domain. This paper introduces the background and significance of constructing a historical architectural database for Wudang Lamasery, outlines the main framework and content of the database, and explores the application and development of a digital database platform in the management and preservation of Wudang Lamasery's architecture. Through this research, the aim is to contribute to the protection, management, study, and restoration of Wudang Lamasery's architecture, as well as to the establishment of a digital museum. By leveraging information technology, people can transcend the constraints of time and space, experiencing the historical depth, cultural significance, and unique architectural charm of Wudang Lamasery in diverse ways.

However, this study still has certain limitations, such as the completeness of data collection, the level of intelligence in the database, and the inadequacies in open sharing mechanisms. Future research directions could focus on intelligent data collection and processing, multi-source data integration and knowledge graph construction [27], virtual reality and immersive experiences, the application of blockchain[28] and digital twin technologies, as well as interdisciplinary research and international collaboration. Through the application of cutting-edge technologies and multidisciplinary collaboration, the construction of the Wudang Lamasery architectural database will not only provide stronger technical support for the preservation and inheritance of cultural heritage, but also pave new paths for the innovative development of Tibetan Buddhist architectural research.

Author Contributions

Conceptualization, M.W.; methodology, M.W.; software, M.W.;validation, M.W. and H.H.; resources, M.W. and Y.P.; data curation, H.H. and Y.P.; writing—original draft preparation, M.W.; writing—review and editing, M.W. and H.H.; visualization, M.W. and Y.P.; supervision, H.H.; project administration, H.H.; funding acquisition, M.W. and Y.P. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Wang, J., Seyler, B. C., Phuntsok, T. S., Lu, Y., & Tsomo, L. Traditional beliefs, culture, and local biodiversity protection: An ethnographic study in the Shaluli Mountains Region, Sichuan Province, China. *Journal for Nature Conservation*, 2022, *68*, 126213.
2. Arbace, L., Sonnino, E., Callieri, M., Dellepiane, M., Fabbri, M., Idelson, A. I., & Scopigno, R. Innovative uses of 3D digital technologies to assist the restoration of a fragmented terracotta statue. *Journal of Cultural Heritage*, 2013, *14*(4), 332–345.
3. Liu, L., & Li, Y. Protection, restoration, and display of historical architectural sites: A case study of Gengpi Zhao in Wudang Zhao, Inner Mongolia. *Journal of Beijing University of Civil Engineering and Architecture*, 2010, (1), 1–4, 9.
4. Qilegeer. The embodiment of Atisha in Tibetan Buddhist art in Inner Mongolia: A case study of Wudang Zhao and Meidai Zhao. *Voice of Dharma*, 2022, (1), 40–45.

5. Zhang, P. Research on the architectural forms of Tibetan Buddhism in Inner Mongolia. *Tianjin University*, 2014.
6. Li, Y. *One Dust, One Moment,* One Tower: Temple Volume. *Beijing University of Technology Press*, 2013.
7. Meng, C., Zhang, S., & Li, X. Analysis of the spatial characteristics of faith in the Tibetan Buddhist temple Wudang Zhao. *New Architecture*, 2020, (2), 138–142.
8. Earl, G., Martinez, K., & Malzbender, T. Archaeological applications of polynomial texture mapping: analysis, conservation, and representation. *Journal of Archaeological Science*, 2010, *37*(8), 2040–2050.
9. Wang, J. Application of digital media technology in the protection of historical buildings. *Housing Science*, 2020, (3), 34–36, 42.
10. Amato, F., Moscato, V., Picariello, A., Coles, F., De Santomassimo, Schreiber, F. A., & Tancalzi, Z. Big Data Meets Digital Cultural Heritage. *Journal on Computing and Cultural Heritage*, 2017, *10*(1), 1–23.
11. Hang, S., & Yan, Y. The impact of digital technology on architectural heritage protection. *Architectural Technology Development*, 2021, (10), 71–73.
12. Lin, C. Bridging tradition and technology: Research on digital protection and adaptive reuse of historical buildings. *New Architecture*, 2009, (3), 109–114.
13. Kamariotou, V., Kamariotou, M., & Kitsios, F. Strategic planning for virtual exhibitions and visitors' experience: A multidisciplinary approach for museums in the digital age. *Digital Applications in Archaeology and Cultural Heritage*, 2021, *21*, e00183.
14. Li, J., Zheng, X., Watanabe, I., & Ochiai, Y. A systematic review of digital transformation technologies in museum exhibition. *Computers in Human Behavior*, 2024, *161*, 108407.
15. Wang, X. Challenges and countermeasures of digital media in the landscape architecture design industry. *Architectural Design Management*, 2016, (1), 66–67, 76.
16. Anastasovitis, E., & Roumeliotis, M. Transforming computed tomography scans into a full-immersive virtual museum for the Antikythera Mechanism. *Digital Applications in Archaeology and Cultural Heritage*, 2023, *28*, e00259.
17. Atik, M. E., Duran, Z., Yanalak, M., Seker, D. Z., & Ak, A. 3D modeling of historical measurement instruments using photogrammetric and laser scanning techniques. *Digital Applications in Archaeology and Cultural Heritage*, 2023, *30*, e00286.
18. Cardia, S., Langella, F., Pagano, M., Palma, B., Sabato, L., Tropeano, M., & Parise, M. 3D digital analysis for geo-structural monitoring and virtual documentation of the Saint Michael cave in Minervino Murge, Bari (Italy). *Digital Applications in Archaeology and Cultural Heritage*, 2024, *32*, e00308.
19. Zhang, P., Ling, Y., Guo, L., Zhang, J., & Ji, Y. Construction and application of a knowledge management platform for Bohai Oilfield projects. *Computer Knowledge and Technology*, 2021, (30), 145–147, 150.
20. Song, T., Wang, Y., & Lü, S. Overview of AngularJS technology in next-generation internet applications. *Science & Technology Vision*, 2016, (19), 237, 277.
21. Ren, J. Exploration of computer-based digital protection of historical buildings in Alashan Prince's Mansion. *Shanxi Architecture*, 2023, (20), 16–19, 41.
22. Zhang, Z., Zhang, J., Cao, Y., Chen, M., & Cui, P. Multidimensional organization methods and distributed heterogeneous database storage for geographic entity data. *Journal of Spatio-Temporal Information*, 2025, 1–20.
23. Cheng, G., Shen, W., He, S., & Zhang, K. Research on the routing mechanism of the Express framework in Node.js. *Industrial Control Computer*, 2016, *29*(8), 101–102.
24. Zhang, K. Research on the construction of a traditional architectural style database: A case study of traditional Bayu architecture. *Chongqing University*, 2022.
25. Yao, M., & Wu, Y. Research and practice of virtual simulation technology in architectural heritage protection. *Heritage and Preservation Research*, 2018, *3*(5), 66–70.

26. Bugeja, M., & Grech, E. M. Using Technology and Gamification as a Means of Enhancing Users' Experience at Cultural Heritage Sites. In *Rediscovering Heritage Through Technology*. Springer, Cham, 2020: 69–89.
27. Xie, Y., Wang, J., Li, N., & Cong, Y. Construction of a knowledge graph for Shanghai's outstanding historical buildings. *Housing Science*, 2024, (4), 42–46.
28. Chen, F. Research on the digital protection of Wuhan's modern historical architectural information based on HBIM model technology: A case study of the Eastern Orthodox Church in Hankou. *Wuhan Textile University*, 2023.