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Rediscovering spatial configurations and cultural symbolism in Beijing's official Pailou through landmark spatial indexing

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ABSTRACT

The preservation and understanding of architectural heritage face growing challenges due to rapid urbanization and globalization. This study investigates Beijing's official Pailou, rediscovering its dual role as a spatial marker and cultural transmitter through the Landmark Spatial Indexing (LSI) framework. Integrating Peircean semiotics with the CIDOC Conceptual Reference Model (CIDOC CRM), the research classifies Pailou into three spatial configurations: point, line, and enclosure. Through analyzing 18 spatial indexes from six key locations, the study explores how Pailou anchors ceremonial nodes, connects urban pathways, and defines sacred boundaries. Using digital mapping and visual editing techniques, the transformation of Pailou from functional gateways to ceremonial landmarks during the Yuan, Ming, and Qing dynasties is synthesized, highlighting their roles in representing imperial authority, Confucian ethics, Buddhist philosophy, Daoist philosophy, and cosmological symbolism. Positioned as a mediator between tangible urban spaces and intangible cultural heritage, Pailou embody a unique interplay of spatial and symbolic elements. This study offers a replicable framework for analyzing spatial and cultural relationships in architectural landmarks. The integration of digital tools with traditional heritage methodologies demonstrates their value for urban conservation and planning, reinforcing the cultural relevance of Pailou in contemporary contexts.

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Beijing official Pailou; landmark spatial indexing; peircean semiotics; CIDOC CRM; cultural symbolism

1. Introduction

Cultural heritage is essential for connecting collective memory and urban identity, serving as the foundation for cityscapes and connectivity among people. However, globalization and urbanization pose a threat to its preservation and transmission. Safeguarding traditions goes beyond merely protecting cultural heritage; it also plays an important role in urban planning and sustainable development while reinforcing local identity (Loughran, Fine, and Hunter 2015; Naheed and Shooshtarian 2022; Sauarlia and Wang 2021).

Architectural heritage, along with its embedded symbolism, plays a critical role in defining urban landscapes. Architectural structures encapsulate tangible and intangible cultural meanings by weaving historical narratives into modern urban frameworks. Landmarks, as cultural nodes, shape the formation of urban spaces and social interactions (Chen et al. 2021). Beyond their navigational roles, these landmarks reinforce urban identity and social cohesion through collective memory (Bala 2016; Zappulla, Suau, and Fikfak 2014). However, current research often underexplores how architectural heritage reconfigures urban landscapes through spatial arrangements and cultural symbolism, leaving significant gaps in our understanding.

Beijing, as a historic capital and cultural-political hub, offers a compelling case for addressing these gaps. During the Yuan, Ming, and Qing dynasties, Pailou delineated neighborhoods, symbolized social units, and guided spatial behavior (Deng and Mao 2003; Wang 2023). The city's architectural evolution reflects centuries of cultural integration, with Pailou standing as an emblematic marker of its social, cultural, and spatial narrative. Traditionally, Pailou, also referred to as Paifang, has been categorized into roofed and columnar forms (Zheng 2010); this research collectively refers to them as Pailou for clarity. Historically, Pailou has served as a decorative marker and spatial signifier of social order, cultural values, and ceremonial practices. Positioned strategically at urban nodes such as temple entrances and along the city's central axis, Pailou embodies Confucian hierarchical principles and imperial authority. The Lingxing-men at the Temple of Heaven symbolizes the transition from secular to sacred realms, embedding cosmological and cultural ideals into the city's spatial framework (Wang 2007).

Despite its cultural significance, Pailou has largely been overlooked in heritage conservation and

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academic discourse (Jin 2003). Often dismissed as "minor structures," they lack independent evaluative frameworks. During the nomination of Beijing's Central Axis as a UNESCO World Heritage Site (UNESCO 2024), Pailou was briefly mentioned. Many historically significant Pailou along the axis, such as those near the Zhengyang Bridge and the East and West Four intersections, have been demolished or relocated due to modernization. Furthermore, the proliferation of low-quality replicas has further distorted public perception, significantly diminishing the historical and cultural value of Pailou. This physical transformation partially reflects inadequacies in safeguarding cultural and spatial values. The Principles for the *Conservation of Heritage Sites in China* clearly state that heritage conservation should not only focus on the physical integrity of buildings, but also comprehensively address the value, value carriers, and environmental elements that reflect the significance of cultural relics. Moreover, the historical evolution of heritage sites, including their distinctive characteristics from different eras and valuable physical remains, should be fully respected (ICOMOS China 2015).

Globally, landmark structures are increasingly recognized for their roles in reinforcing urban identity and shaping cultural narratives (Zappulla, Suau, and Fikfak 2014). However, a critical research gap persists: How can the cultural significance of Beijing's official-style Pailou be rediscovered through spatial configuration and symbolic encoding?

This research proposes an original integrated analytical framework combining a novel analytical approach – Landmark Spatial Indexing (LSI) – with CIDOC CRM ontology and Peircean semiotics to reinterpret the spatial configurations and cultural symbolism of Beijing's official Pailou. Unlike previous studies that primarily focused on historical documentation, architectural styles, or descriptive typologies, this study advances heritage research by systematically linking spatial arrangements with explicit cultural and symbolic meanings. LSI categorizes Pailou into three spatial configurations (Point, Line, Enclosure) to systematically analyze their ceremonial and spatial roles within urban contexts. CIDOC CRM further provides a structured semantic encoding for spatial, temporal, and symbolic dimensions (CIDOC CRM Special Interest Group 2024), while Peircean semiotics decodes embedded indexical signs. By visually examining 18 spatially indexed Pailou across six key locations, this study clarifies their dual functions as spatial markers and cultural transmitters, highlighting how their spatial positioning and symbolic attributes historically structured ceremonies, reinforced hierarchical orders, and embodied specific cultural values. Thus, this integrated analytical approach extends significantly beyond traditional heritage studies, offering a systematic, replicable methodology that enhances both theoretical understanding and practical heritage conservation by addressing both historical authenticity and contemporary applicability.

These findings contribute to architectural semiotics and cultural heritage studies while also offering practical insights for urban planning and heritage conservation. This article is structured as follows: Section 2 reviews the literature on spatial semiotics and architectural symbolism. Section 3 outlines the methodology, detailing the integration of CIDOC CRM and LSI. Section 4 presents the results, highlighting the spatial and cultural significance of Pailou. Finally, Section 5 discusses the implications and suggests future research directions.

2. Literature review

2.1. CIDOC CRM and geospatial analysis in cultural heritage

In recent years, there has been growing interest in integrating semantic networks, geospatial analysis, and CIDOC CRM in cultural heritage studies. CIDOC CRM (Conceptual Reference Model) is a standardized semantic ontology developed for the documentation of cultural heritage information, facilitating the structured integration and interpretation of data across different sources (CIDOC CRM Special Interest Group 2024). CIDOC CRM, functioning as a conceptual reference framework, enables semantic interoperability by connecting spatial, temporal, and cultural elements (Moraitou et al. 2019). Within this model, the notion of "Spacetime Volume" distinguishes the physical and temporal aspects of events from their human interpretations and provides a systematic way of studying the geographical distribution and historical development of cultural sites. The organization of multidimensional information is essential and has been widely adopted in many cultural heritage initiatives using this framework (Ducatteeuw 2021).

Despite these improvements, current studies have identified some constraints, such as the disintegration and limited compatibility resulting from the swift expansion of digital cultural heritage information (Nishanbaev, Champion, and McMeekin 2019). In addition, geospatial semantic networks provide technical solutions but often lack a strong conceptual structure, which prevents their wider adoption (Bruns and Chamberlain 2019). These observations underscore the need to devise a comprehensive framework to systematically explore cultural landmarks and extract theoretical concepts related to heritage administration.

These issues are addressed by CIDOC CRM, which provides a methodological basis for integrating disparate data sources into a unified structure. CIDOC CRM combines spatial, temporal, and cultural elements into a single semantic framework, enabling a systematic

study of the geographical distribution, chronological development, and symbolic significance of cultural sites. This functionality validates the choice of this model as the preferred model for this research since it connects disconnected data and provides robust conceptual tools to deal with the complexity of cultural heritage administration.

2.2. Spatial semiotics and indexical signs in architectural studies

According to Peirce (1991), indexical signs convey meaning through direct physical, causal, or spatial connections with the object they represent. Peircean semiotics, derived from the philosopher Charles Sanders Peirce, categorizes signs into three types – icons (based on resemblance), indices (based on direct physical or causal connection), and symbols (based on convention) – to systematically analyze the meaning and communication embedded within various media, including architecture. The study of the spatial and symbolic function of cultural landmarks shows how a critical semiotic approach plays a crucial role in theory. Spatial anchors, with their physical presence and symbolic attributes, contribute to cultural identity, guide social behaviors, and become landmarks (Chen et al. 2021; Montello and Raubal 2013). Indexical signs play a dual role in cultural heritage, as they connect historical narratives with contemporary spaces, shaping both social memory and spatial cognition (Ahmadpoor, Smith, and Heath 2021).

In Beijing's Pailou, indexical signs serve as cultural anchors that encapsulate hierarchical values and rituals. Pailou symbolizes the transition between sacred and secular spaces through its spatial configurations – Point, Line, and Enclosure. Spatial meanings are not only physical but also cultural, and space is a "text" that can be interpreted through semiotic, cultural, and philosophical approaches (Lavrenova, Filippova, and Khokholova 2023).

However, prior semiotic studies on architectural landmarks often neglect structured semantic encoding, which limits systematic heritage interpretation. Hence, this study develops a robust interpretive approach previously unexplored in architectural heritage research by explicitly integrating Peircean semiotics with CIDOC CRM and digital mapping techniques.

2.3. Pailou as cultural and spatial indices

Architectural traditions have widely explored geometric elements such as points, lines, and enclosures as cultural connotations (Goubran 2019; Koh and Lim 2023). Scholars have also recognized these elements as fundamental in shaping ceremonial and cultural spaces. According to Hingley, Vermander, and Zhang (2016), boundary functions and cultural assimilation play essential logics in rendering spaces sacred, while Kang and Yu (2022) highlight how rituals serve as symbols that perpetuate cultural memory and group identity. These studies emphasize the dual role of spatial components in expressing sanctity and cultural significance. In the case of Beijing's Pailou, these configurations (points, lines, and enclosures) are assigned different symbolic and spatial functions. Points act as central markers, signifying notable events or spatial transitions. Lines connect significant locations, guiding movement and ensuring spatial continuity. Enclosures delineate scared spaces, marking transitions from secular to ceremonial realms. The cultural symbolism through these geometric forms, integrated into urban landscapes, strengthens their ceremonial and spatial roles.

Pailou function as spatial indicators that shape urban environments while serving as vessels of cultural heritage, complementing the broader narrative of city planning. Through their symbolic representations, these structures maintain communal recollections and cultural distinctiveness. The *"Birthday Celebration for the Empress Dowager Chongqing,"* consisting of four long scrolls, vividly depicts the ceremonial routes of the Qing Dynasty (Lin 2019, 2020; L. Liu 2014, 2015). The repeated appearance of the Pailou throughout the scrolls highlights their significance as ceremonial markers, further reinforcing their imperial authority and cultural cohesion. The South Pailou of Longevity Hill in the Qingyi Garden (the predecessor of the Summer Palace), known as the "Yunhui Yuyu" Pailou, was originally constructed during the Qianlong reign (1750), marking the starting point of the central architectural axis at the front of Longevity Hill. At that time, three Pailou structures were erected along the axis and its eastern and western flanks, symbolically designating the area as the starting point for longevity celebrations and religious activities where officials would await imperial summons (Figure 1). However, these structures were destroyed in 1860. During the Guangxu reign, Empress Dowager Cixi rebuilt only the Pailou along the central axis, inscribing it with the name



Figure 1. The *"birthday celebration for the Empress dowager Chongqing,"* volume I. South Pailou of Longevity Hill, Qing dynasty painting by Zhang Tingyan et al. 1751.



Figure 2. The "*birthday celebration for the Empress dowagerDowager Chongqing*," volume III. West Fourth Pailou, Qing dynasty painting by Zhang Tingyan et al., 1751.

"Yunhui Yuyu." Thus, the existing Pailou dates back to the Guangxu period reconstruction. Within this spatial sequence, this site served as the starting point for ceremonial activities. Similarly, the Pailou group in West Fourth vividly demonstrates the spatial divisions and functional organization of Qing Dynasty cities, guiding ceremonial flows (Figure 2). Meanwhile, the Pailou at the inner and outer gates of Xizhimen served as key connectors between the imperial city and its surrounding areas, further reinforcing ritual and symbolic systems (Figure 3). As critical spatial nodes, these Pailou not only structured the spatial order of ceremonial activities, but also reinforced the Qing Dynasty's political and social frameworks through their visual and cultural symbolism.

2.4. Challenges in the conservation of Pailou

Despite its cultural significance, Pailou has been increasingly overlooked in academic discourse and heritage conservation. Of the over 300 structures in the Ming and Qing dynasties, only 65 remain today, many now endangered by urbanization and modernization (Zheng 2010). The lack of independent evaluative frameworks has led to the proliferation of low-quality replicas that distort cultural symbolism. Moreover, many existing studies dismiss them as "minor structures" or "street furniture" within the vast tapestry of Chinese cultural relics, failing to accord Pailou with the independent evaluative criteria they deserve. Although Beijing's Central Axis was inscribed on the World Heritage List at the 46th session of the UNESCO World Heritage Committee (UNESCO 2024), Pailou was mentioned only in passing.

3. Methods

3.1. Research design

This study adopted a multidisciplinary approach to examine the spatial configurations and cultural symbolism of Beijing's official Pailou. Landmark Spatial Indexing (LSI), an original analytical approach developed in this research, categorized landmarks into three spatial configurations – point, line, and enclosure – based on their ceremonial and urban functions. By integrating LSI with the CIDOC Conceptual Reference Model (CIDOC CRM) and Peircean semiotics, this study established a comprehensive analytical framework that systematically encodes spatial, temporal, and symbolic attributes of architectural heritage. This integration forms a reproducible analytical framework with significant reference value for urban heritage conservation and cultural interpretation, facilitating a systematic exploration of how Pailou shapes urban landscapes and embodies cultural narratives.

Unlike conventional spatial analysis methods, such as space syntax, GIS-based heat maps, Kernel Density Estimation (KDE), or spatial autocorrelation analyses (e.g., Moran's I, LISA), which primarily quantify spatial clusters and statistical patterns (Roy and Chowdhury 2024, 2025), LSI uniquely emphasizes symbolic-cultural interpretations, making it particularly suitable for architectural heritage analysis. This research hypothesized that LSI would reveal consistent symbolic-spatial patterns that reflect cultural hierarchies, ceremonial order, and spatial meanings. CIDOC CRM systematically encodes these multidimensional attributes, ensuring semantic clarity and interoperability. Complementing this, Peircean semiotics decodes the indexical signs embedded within the spatial and symbolic structures of Pailou, further enriching theoretical discourse.

Although originally developed within the context of Beijing, the structured analytical framework presented here demonstrates broader potential applicability and could be adapted to heritage conservation projects in other urban contexts, offering insights into landmark



Figure 3. The *"birthday celebration for the Empress Dowager Chongqing,"* volume III. Inner and outer pailou of Xizhimen, Qing dynasty painting by Zhang Tingyan et al., 1751.

Table 1. Components of the integrated analytical framework.

Component	Description
Landmark Spatial Indexing (LSI)	Analytical approach identifying geographical locations and spatial layouts of Pailou based on their ceremonial and urban roles.
Peircean Semiotics	Interpretive theory for decoding cultural significance through indexical signs, symbols, and imagery.
CIDOC CRM	The ontological model systematically encodes historical, spatial, and symbolic attributes through structured classes and properties (E, P).

structures and their symbolic-spatial roles in diverse settings.

To clearly illustrate how these theoretical components interact, their respective functions are summarized below (Table 1).

3.2. Theoretical foundations

The theoretical framework for this study integrates Charles Sanders Peirce's semiotic theory with the CIDOC CRM ontology. Peirce's semiotic theory categorizes signs into three types – icons, indices, and symbols – based on their relationships with the objects they represent. Icons are signs that resemble their objects, such as photographs or realistic paintings. Indices signify their objects through direct physical, spatial, or causal connections, like smoke indicating fire or footprints marking someone's passage. Symbols derive their meanings through social conventions, such as language or traffic signs.

In the context of Pailou, the concept of indexical signs is particularly relevant, as these architectural structures directly embody and convey broader cultural narratives through their spatial positioning and forms. A point Pailou acts as a standalone marker of significant ceremonial sites or key urban intersections. A line Pailou delineates ceremonial routes, guiding movement and ensuring spatial continuity. An enclosure Pailou signifies a transition from the mundane to the sacred realm, marking distinct ceremonial or sacred precincts. Collectively, these spatial configurations illuminate Pailou's dual role as both navigational landmarks and cultural transmitters, embedding Confucian principles, Buddhist and Daoist tenets, and imperial authority into Beijing's urban fabric.

CIDOC CRM, developed by the International Committee for Documentation (CIDOC), is an ontology designed to standardize and harmonize cultural heritage data. As a key initiative of CIDOC, the Conceptual Reference Model (CRM) defines structured classes (E) and properties (P), establishing a robust semantic network for systematically organizing and interpreting complex cultural information. By explicitly linking spatial, temporal, and symbolic dimensions (e.g., E53 Place, E52 Time-Span, E90 Symbolic Object, E92 Spacetime Volume, P168 place is defined by, and P190 symbolic content), CIDOC CRM significantly enhances the understanding of spatial relationships. Unlike alternative spatial ontologies like GeoSPARQL (which emphasizes spatial querying and interoperability) and BIM-GIS integration (which integrates building-level details with broader geographic contexts), CIDOC CRM not only explicitly encodes the cultural and historical contexts critical to heritage analysis, but also provides a hierarchical structure for representing cultural narratives, making it uniquely suitable for analyzing architectural heritage characterized by intricate symbolic meanings.

This study applied CIDOC CRM (version 7.3) to encode and interpret Pailou's characteristics geographically, temporally, and culturally. Key CRM classes systematically link spatial configurations with symbolic interpretations, providing structured semantic clarity to complex heritage narratives. Specifically, E53 (Place) designates the geographical location of heritage objects, such as the precise spatial positioning of the Qianmen Street Pailou within Beijing's urban landscape. E92 (Spacetime Volume) encapsulates both spatial and temporal dimensions – for instance, the Temple of Heaven's Lingxing-men Paifang structures exist within a clearly defined ceremonial space and a historical era of Qing Dynasty imperial rites. E90 (Symbolic Object) denotes the symbolic meanings embedded in these architectural forms, such as the Yonghe Temple Pailou symbolizing religious harmony and imperial authority. These categories collectively allow CIDOC CRM to clearly articulate how the spatial and symbolic aspects of heritage sites intertwine with their historical contexts, significantly enhancing interpretive depth.

3.3. Data collection and analysis

Data were collected from 18 representative official-style Pailou structures across six key heritage sites in Beijing: Qianmen Street, the Temple of Heaven, Yonghe Temple, the Imperial College (Guozijian), Beihai Park, and the Summer Palace. These sites were selected according to three primary criteria: historical significance, architectural integrity, and representative geospatial distribution. Specifically, sites were chosen for their documented cultural relevance, well-preserved architectural authenticity, and clear spatial configurations. Qianmen Street and the Temple of Heaven were included due to their pivotal roles in imperial ceremonies and foundational functions in structuring Beijing's urban layout. Yonghe Temple and Guozijian highlight the integration of religious

and educational purposes, underlining their cultural and institutional importance. Beihai Park and the Summer Palace illustrate the fusion of natural landscapes with architectural symbolism, embodying imperial aesthetic ideals and cosmological principles. Collectively, these locations provide comprehensive coverage along Beijing's central axis and some adjacent ceremonial areas, effectively illustrating intersections between urban heritage, ceremonial traditions, and spatial symbolism. However, this research acknowledged a selection bias toward imperial official styles rather than civil styles; thus, future studies could broaden the analytical scope to include more diverse civil-style Pailou or Paifang for comparative analysis.

Field observations were systematically conducted through structured site visits, incorporating high-definition photographic records and spatial renderings of each Pailou's façades, surrounding environments, and spatial configurations. Standardized field notes meticulously recorded architectural conditions, geospatial coordinates, spatial arrangements, and symbolic details. To ensure data reliability and accuracy, these observations were cross-verified with historical records from CNKI databases and Qing Dynasty documentation. Multiple site visits and comparative reviews further validated data consistency.

Archival materials, including Qing Dynasty paintings, historical texts, and CNKI records, provided essential context about the construction, evolution, and symbolic meanings of selected Pailou. Digital cartographic tools – Google Earth Pro and Photoshop – were employed to enhance spatial precision and analytical clarity. Google Earth Pro facilitated precise mapping of geographical locations, orientations, and ceremonial routes, while Photoshop enabled visual comparisons through overlays of historical and contemporary maps. Key visual indicators, including color coding, structural delineation, and directional symbols, were strategically applied to emphasize Pailou's dual roles as wayfinding elements and cultural markers. This integrated digital approach demonstrated significant advantages for heritage documentation, spatial analysis, and cultural conservation.

3.4. Framework for Pailou LSI and CIDOC CRM code

This research proposes an integrated analytical framework to systematically analyze the spatial and symbolic aspects of 18 LSI Pailou in six chosen locations in Beijing through the combination of Landmark Spatial Indexing (LSI) and CIDOC CRM codes. Six main CIDOC CRM E-class categories (E53 Place, E52 Time-Span, E90 Symbolic Object, E92 Spacetime Volume, E22 human-Made Object, and E36 Visual Item) were chosen for their capacity to fully represent the spatial, temporal, and symbolic aspects of Pailou. These categories allow spatial arrangements and symbolic significance to be encoded and provide a structured way of connecting Pailou to broader urban narratives and cultural heritage practices.

The framework is divided into three analytical strata, amalgamating spatial, temporal, and symbolic elements. The foundational stratum, LSI Context, served as the basic backdrop, systematically storing spatial, temporal, and symbolic elements to create a fundamental backdrop for Pailou. Key CIDOC CRM classes, including E53 Place and E52 Time-Span, were employed to anchor Pailou within their geographic and historical settings. This layer emphasizes the relationships between Pailou's spatial locations and their cultural and ceremonial significance (Figure 4).

The second layer focuses on LSI Configuration Patterns, categorizing Pailou into Point, Line, and Enclosure using CIDOC CRM properties, such as P2 (has type) and P46 (composed of). This categorization highlights the functional and symbolic roles of Pailou in ceremonial pathways and urban landscapes.

The third layer addresses symbolic interpretations by integrating spatial semiotics with CRM properties such as P190 (symbolic content) and E36 Visual Items. These properties decode cultural narratives embedded in Pailou's spatial forms and symbolic content. This layer bridges architectural semantics with cultural narratives, revealing how Pailou functions as a cultural carrier in Beijing's urban and ceremonial context.

4. Finding and discussion

4.1. Findings from observations of official Pailou LSI across six locations

The spatial configurations and symbolic roles of Pailou at six key sites in Beijing were revealed through an analysis of 18 Landmark Spatial Indexing locations identified by Google Maps. This study highlights the critical role of point, line, and enclosure configurations in shaping Beijing's cultural narratives and spatial organization. The following section focuses on the architectural features, ceremonial functions, and cultural symbolism of these LSI locations, recording only the earliest construction dates of the Pailous, with later reconstructions or renovations excluded (Figure 5, and Table 2).

To compare historical and contemporary spatial distributions, the Complete Map of Beijing during the Qianlong Reign (1750) (乾隆京城全图), compiled by the Imperial Household Department, was georeferenced into Google Earth Pro (2025). Since the historical map does not include the Summer Palace, six Pailou (LSI 12–17) were excluded from this historical analysis. Among the remaining twelve structures, LSI locations 5–7, 8 & 9, and 10 & 11 do

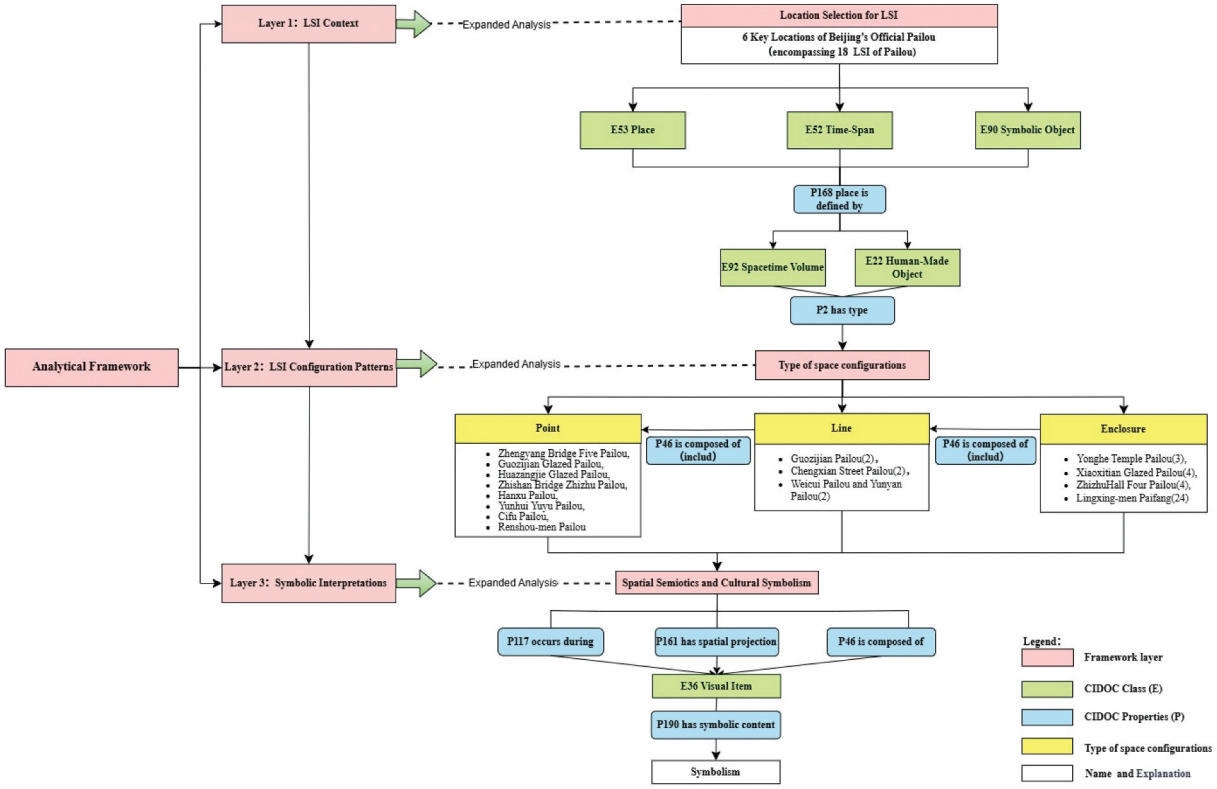


Figure 4. LSI framework based on Peircean semiotics and CIDOC CRM to analyze spatial configurations and symbolism of heritage-Beijing official Pailou.

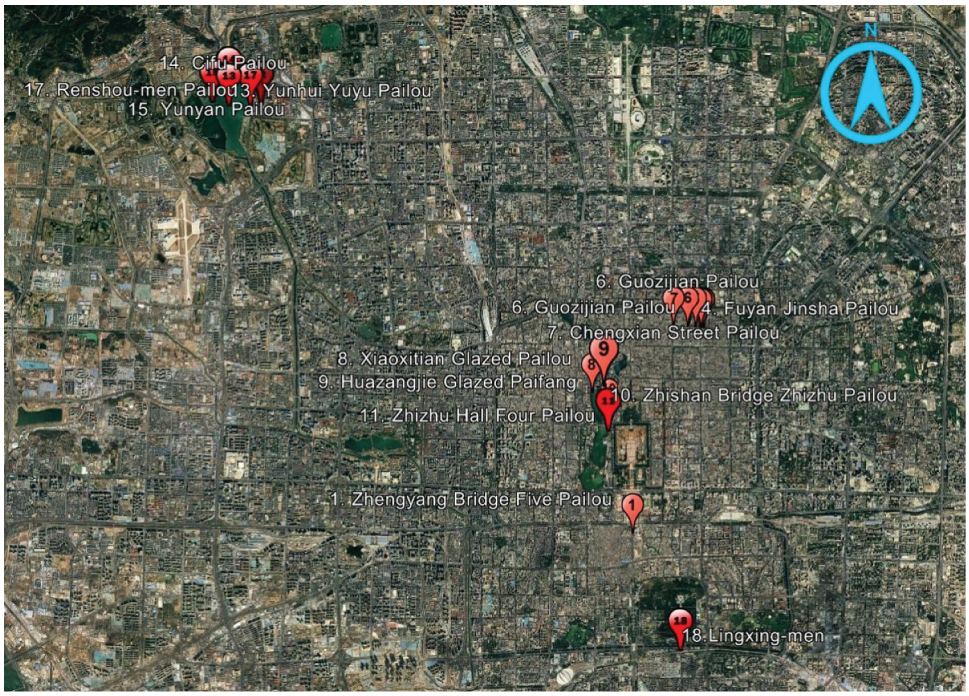


Figure 5. Location of 18 LSI pailou identified in the google maps sequence.

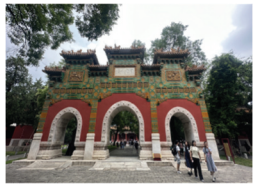
not appear on the 1750 map, suggesting these were constructed after this date (Figure 6, Tables 2 & 3). Additionally, a lot of Pailou documented on the 1750 map no longer exist today; for instance, an original Pailou located between LSI 8 and 9, clearly depicted on the historical map, has since been demolished and does not appear in contemporary imagery. Such cases illustrate that the historical analysis identified and acknowledged demolished or missing structures by noting their original positions, thus enhancing the accuracy and depth of spatial comparisons. Critically, these instances of heritage

Table 2. Symbolism and spatial organization of Beijing's official pailou in cultural heritage.

Location	Name of Pailou	Time	Group/ single	Situated in space	Type of space configurations	Form	Serial number on Google Maps	Image	Symbolism
Qianmen Street	Zhengyang Bridge Five Pailou	1439 (Ming Dynasty)	Single	Front of the Beijing Central Axis	Point	Rushing to the sky-style Pailou (Six-pillar, five-bay, five-roof)	1		Represents imperial authority and Confucian ideals, marking the ceremonial gateway.
Yonghe Temple	Yonghe Temple Pailou(3): Huanhai Zunqin Pailou, Cilong Baoye Pailou, Fuyan Jinsha Pailou	1744 (Qing Dynasty)	Group	Three directional ends of the crosshairs	Enclosure	Building-style Pailou (Four-pillar, three-bay, nine-roof)	2		Embodies imperial dignity and the central significance of Buddhist culture.
						Building-style Pailou (Four-pillar, three-bay, seven-roof)	3		
						Building-style Pailou (Four-pillar, three span, seven-roof)	4		

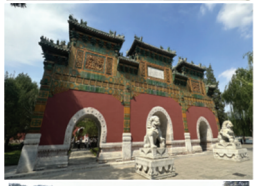
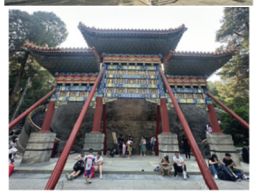
(*Continued*)

Table 2. (Continued).

Location	Name of Pailou	Time	Group/ single	Situated in space	Type of space configurations	Form	Serial number on Google Maps	Image	Symbolism
Guozijian	Guozijian Glazed Pailou	1784 (Qing Dynasty)	Single	On the central axis	Point	Building-style Pailou (Four-pillar, three-bay, seven-roof)	5		Highlights imperial support for Confucian education and cultural enlightenment.
	Guozijian Pailou(2)	(Qing Dynasty)	Group	Both ends of the street	Line	Building-style Pailou (Two-pillar, three-bay, three-roof)	6		Connects Guozijian and the Confucius Temple, reflecting Confucian ideals.
	Chengxian Street Pailou(2)	(Qing Dynasty)	Group	Both ends of the street	Line	Building-style Pailou (Two-pillar, three-bay, three-roof)	7		Marks academic precinct boundaries, emphasizing hierarchical order.

(*Continued*)

Table 2. (Continued).

Location	Name of Pailou	Time	Group/ single	Situated in space	Type of space configurations	Form	Serial number on Google Maps	Image	Symbolism
Beihai Park	Xiaoxitian Glazed Pailou(4)	1770 (Qing Dynasty)	Group	Four directional ends of the crosshairs	Enclosure	Building-style Pailou (Four-pillar, three-bay, seven-roof)	8		Represents the Buddhist Pure Land and filial piety within a sacred royal garden.
	Huazangjie Glazed Pailou	1780 (Qing Dynasty)	Single	Front of the central axis	Point	Building-style Pailou (Four-pillar, three-bay, seven-roof)	9		Combines royal ceremonial grandeur with Buddhist religious elements.
	Zhishan Bridge Zhizhu Pailou	1751 (Qing Dynasty)	Single	Front of the central axis	Point	Building-style Pailou (Four-pillar, three-bay, three-roof)	10		Connects sacred and secular spaces in the royal garden.
	Zhizhu Hall Four Pailou(4)	(Qing Dynasty)	Group	Central axis symmetric semi-enclosure	Enclosure	Building-style Pailou (Two-pillar, one-bay, three -roof)	11		Marks a sacred enclosure, reflecting Qing ceremonial design.

(*Continued*)

Table 2. (Continued).

Location	Name of Pailou	Time	Group/ single	Situated in space	Type of space configurations	Form	Serial number on Google Maps	Image	Symbolism
Summer Palace	Hanxu Pailou	1755 (Qing Dynasty)	Single	Front of the central axis	Point	Building-style Pailou (Four-pillar, three-bay, seven-roof)	12		Highlights royal authority and ceremonial order at the Summer Palace's central axis.
	Yunhui Yuyu Pailou	1750 (Qing Dynasty)	Single	Front of the central axis	Point	Building-style Pailou (Four-pillar, three-bay, seven-roof)	13		Embodies the transition from worldly power to spiritual elevation.
	Cifu Pailou	(Qing Dynasty)	Single	Front of the central axis	Point	Building-style Pailou (Four-pillar, three-bay, seven-roof)	14		Marks the gateway to spiritual enlightenment, integrating feng shui and ritual.
	Weicui Pailou and Yunyan Pailou(2)	(Qing Dynasty)	Group	Either end of a bridge	Line	Rushing to the sky-style Pailou (Four-pillar, three-bay, three roof)	15,16		Connect natural and man-made landscapes, symbolizing harmony.
	Renshou-men Pailou	(Qing Dynasty)	Single	Front of the central axis	Point	Building-style Pailou (Two pillar, one-bay, one roof)	17		Serves as a boundary between ceremonial and administrative spaces, symbolizing longevity and unity.
Temple of Heaven	Lingxing-men Paifang(24)	(Ming Dynasty)	Group	Four directional ends of the crosshairs	Enclosure	Rushing to the sky-style Pailou (Two pillar, one-bay, no roof)	18		Symbolizes "Round Heaven, Square Earth" and the integration of rituals with cosmology.

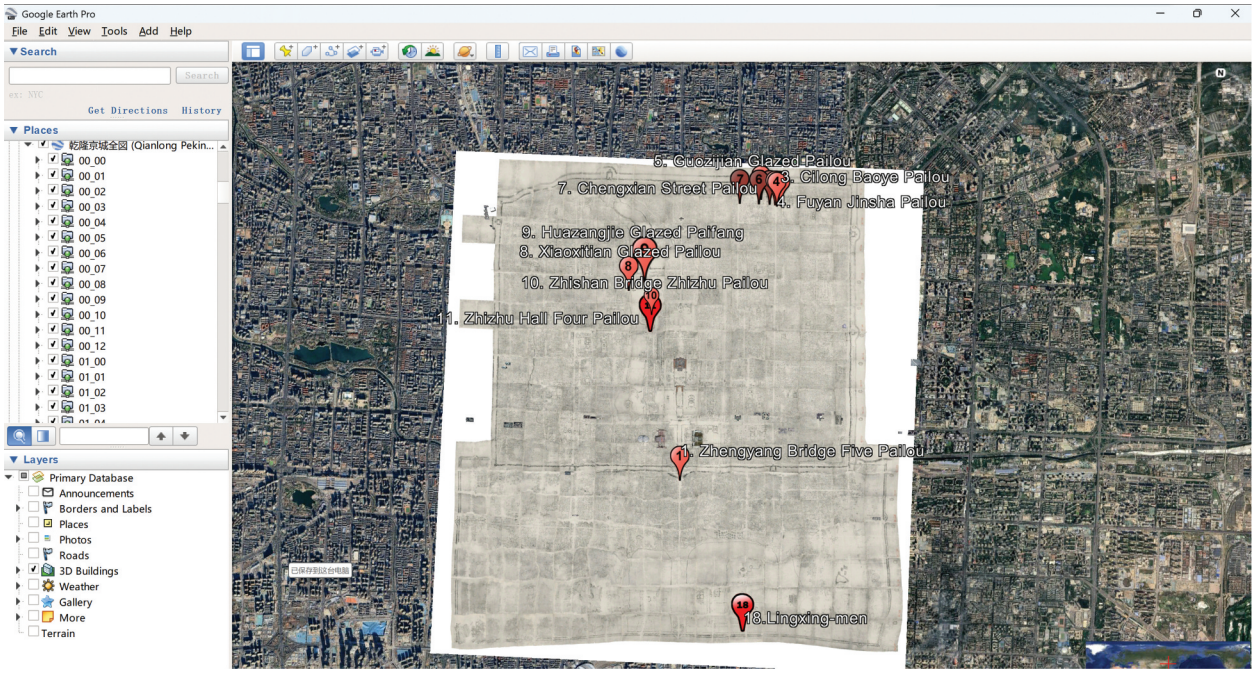


Figure 6. Overlay of the 1750 complete Map of Beijing (Qianlong 15th Year) with contemporary satellite imagery from Google earth pro showing the spatial distribution of 12 LSI pailou.

loss underscore the necessity of future research into urban development policies and heritage management strategies that influenced the preservation or demolition of these culturally significant structures.

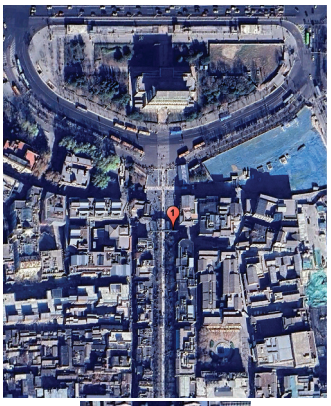
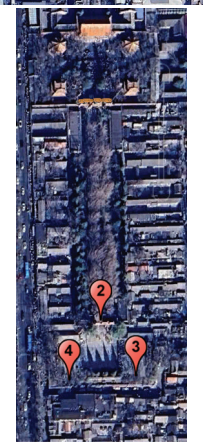
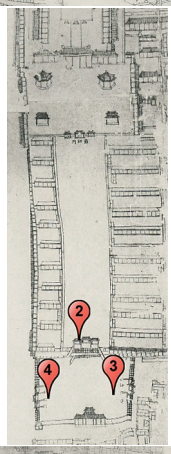
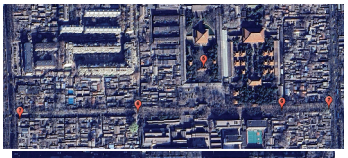
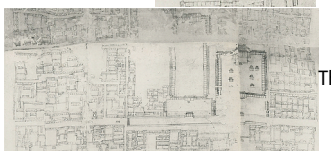
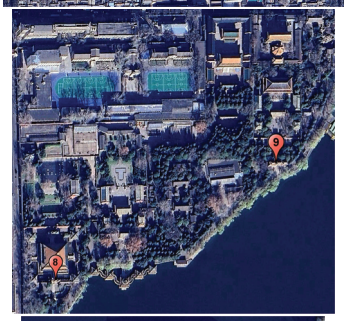
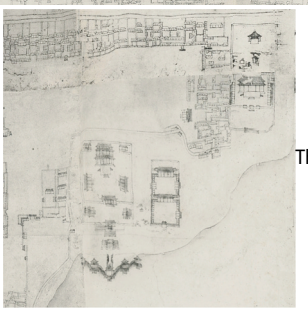
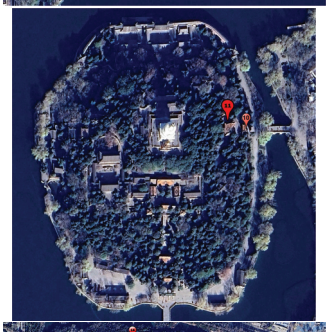
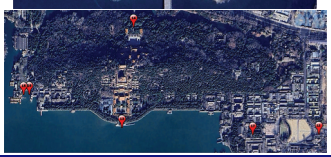
4.1.1. Qianmen street Pailou

Zhengyang Bridge Five Pailou is located at the southern end of Beijing's central axis, marking the starting point of this symbolic urban spine. The central axis, first established in 1267 during Kublai Khan's reign, spans 7.8 km at the heart of Beijing's historic districts. Its symmetrical alignment with the North Star embodies the traditional Chinese cosmological concept of "the unity of heaven and humanity," symbolizing hierarchical order and imperial authority (Figures 7 and 8). Spatial positioning of the Zhengyang Bridge Five Pailou along the central axis, with the Pailou highlighted in red and the axis delineated in yellow. This visualization demonstrates its linear connectivity from the Yongdingmen Gate in the south to the Bell Tower in the north, with the Forbidden City as a central node. This continuity underscores the axis's role as a ceremonial and symbolic conduit linking political and cultural landmarks (Figure 7). The Qianlong reign map reveals the structural and spatial integration of Zhengyang Bridge Five Pailou with Beijing's inner and outer city configurations. The red indicator emphasizes Pailou's role within the imperial city layout, while the orange arrows trace the "Main Road Guidance," aligning the axis with the Imperial Palace and other urban elements. The clear delineation between the Inner City, Outer City, and city walls reflects the spatial hierarchy intrinsic to Beijing's urban design, further emphasizing the cosmological and administrative significance of the axis (Figure 8). This is an outstanding example of ancient Chinese cosmology and urban planning. The "Qianlong Southern Inspection Tour" (Figure 9) prominently features Qianmen Street, emphasizing the area's historical and cultural importance. The Zhengyang Bridge Five Pailou were constructed in 1439 during the Ming era and served as both a key gateway at the axis' beginning and a ceremonial entrance. Its significance in connecting the city's physical layout with its cultural aspects underlines its pivotal role in Beijing's spatial organization and symbolic representation (Deng and Mao 2003; Y. Liu 2023; Qin 2008).

Over the centuries, the Pailou has undergone many transformations, from post-1780 fire renovations and restorations following the Boxer Rebellion to modernization projects for the 2008 Olympics. Its imperial prestige is conveyed through green-glazed tiles, and its symmetrical layout reflects Confucian values of centrality and orderliness. These elements, coupled with its placement along the Central Axis, accentuate its dual purpose as a spatial reference point and a representation of authority and societal structure.

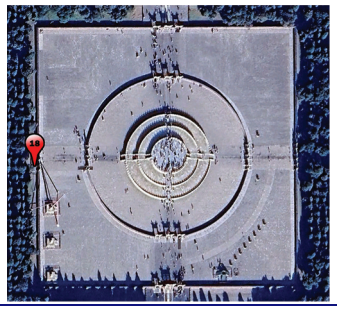
The present structure, with its six pillars, five bays, and five roof arrangements, is an example of the design ingenuity of its period, in the form of a "Rushing to the Sky" architectural motif. It has been recently modified to increase its longevity while keeping its visual harmony, cementing its role as a significant cultural and geographical reference point within Beijing's historical fabric.

Table 3. Comparative visualisation of selected 18 LSI pailou: contemporary satellite imagery (2025) vs. the complete map of Beijing (1750).

LSI No.	The Contemporary Satellite Imagery from Google Earth Pro (2025)	The Complete Map of Beijing during the Qianlong Reign (1750)
1		
2–4		
5–7		 There are no 5–7.
8 & 9		 There are no 8 & 9.
10 & 11		 There are no 10 & 11.
12–17		(None)

(*Continued*)

Table 3. (Continued).

LSI No.	The Contemporary Satellite Imagery from Google Earth Pro (2025)	The Complete Map of Beijing during the Qianlong Reign (1750)
18		

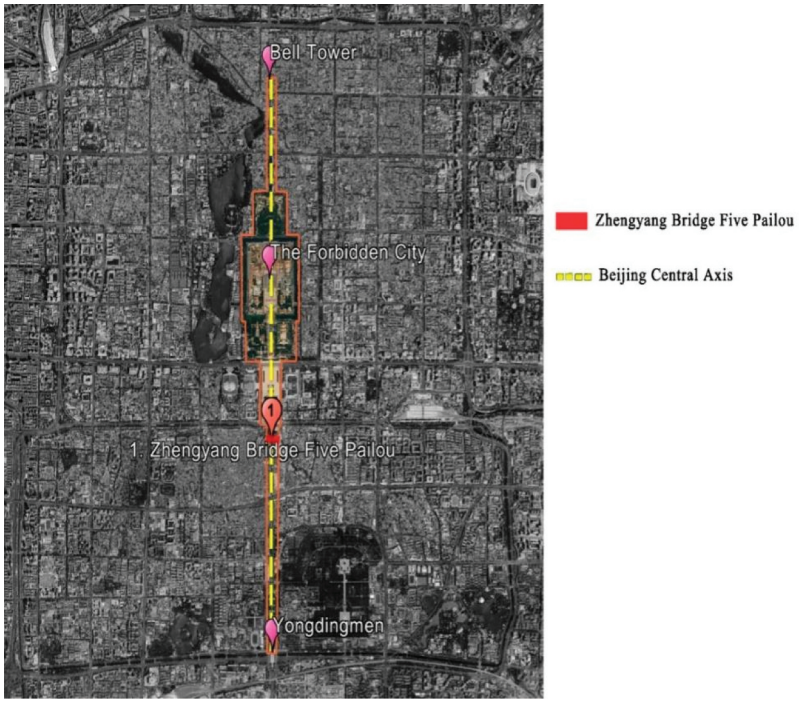


Figure 7. Spatial representation of Beijing's central axis with Zhengyang Bridge five pailou highlighted, Google map.

4.1.2. Pailou of Yonghe temple

Yonghe Temple, constructed in 1694 as a royal residence and subsequently transformed into a Tibetan Buddhist monastery in 1744, exemplifies the Qing Dynasty's integration of spiritual practices with political governance. This establishment demonstrates how the ruling dynasty incorporated religious elements into its administrative framework. The southern entrance is distinguished by three significant Pailou – Huanhai Zunqin, Cilong Baoye, and Fuyan Jinsha – which delineate sacred boundaries and embody ceremonial grandeur (Cui 2019; Guo and Qing 2014; Ma 1985; Su 2023) (Figures 10 and 11).

In these Pailou, the spatial hierarchy and ceremonial coherence are strengthened by the fact that they are located in a symmetric position on the temple's central axis. The Huanhai Zunqin Pailou, with its four pillars and nine roofs, symbolizes imperial authority, whereas Cilong Baoye and Fuyan Jinsha highlight prosperity and protection, respectively. Yellow-glazed tiles and intricate carvings accentuate their architectural significance.

From a semiotic perspective, Pailou integrated Confucian ideals of order and Buddhist principles of inclusivity. Their placement and symbolism underscore Yonghe Temple's role as a ceremonial and cultural landmark, reflecting the Qing Dynasty's synthesis of governance and spirituality.

4.1.3. Pailou of Guozijian

Established in 1306, Guozijian served as the highest educational institution during the Yuan, Ming, and Qing Dynasties. Within its grounds is the Guozijian Glazed Pailou, a four-pillar, three-bay structure representing an imperial commitment to Confucian education. Along Chengxian Street, two additional pairs of Pailou – Guozijian and Chengxian Street Pailou – create a ceremonial axis linking the Confucius Temple with the educational precinct (Figures 10 and 11).

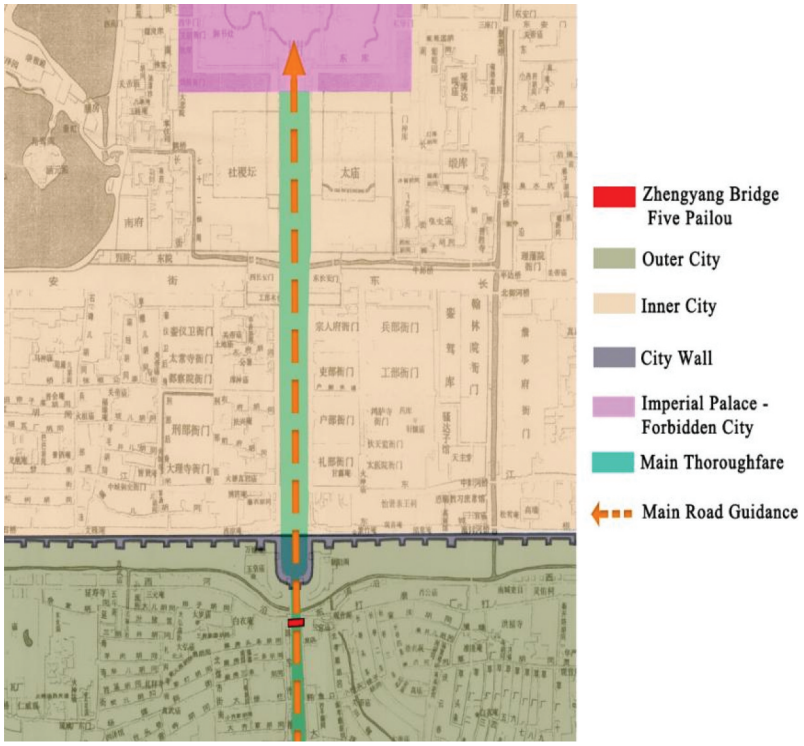


Figure 8. Historical Map Depicting the Zhengyang Bridge Five Paifang in Relation to Beijing's Inner and Outer City Configuration, 'Complete Map of the Capital City during the Qianlong Reign."



Figure 9. The "*Qianlong Southern Inspection Tour*," volume III. Painting by Xu Yang, qing dynasty, 1751.

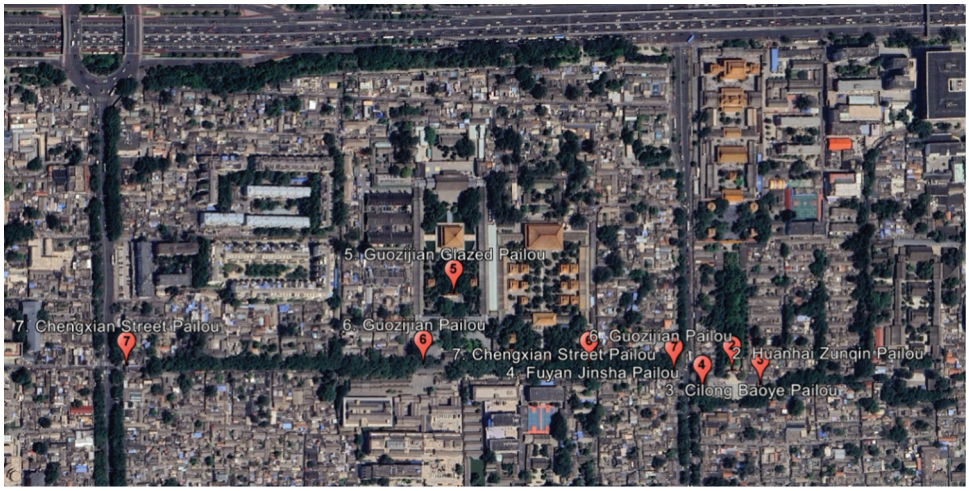


Figure 10. Locating paifang of yonghe temple and guozijian on Google Map.

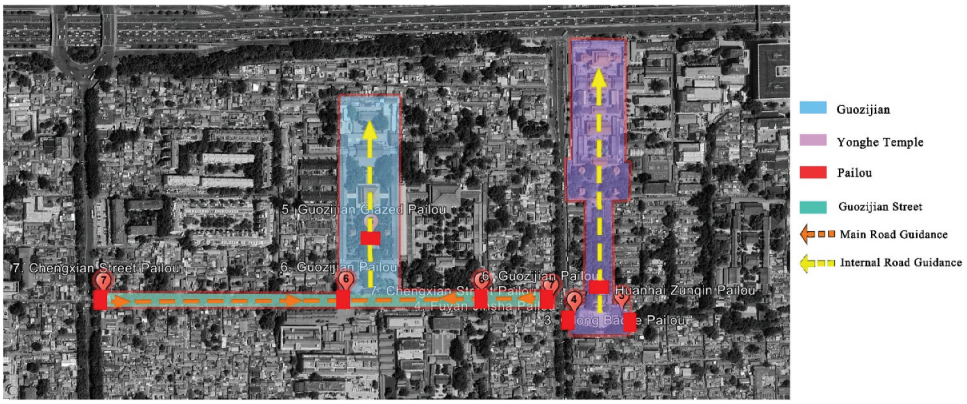


Figure 11. Yonghe Temple and Guozijian.

The Guozijian Glazed Pailou, constructed in 1783 under Emperor Qianlong, features yellow-glazed tiles and inscribed plaques that emphasize educational ideals. Paired Pailou on Chengxian Street, showcasing green glazed tiles and wooden craftsmanship, forms symbolic and physical boundaries for the precinct. These structures, repaired in 1935 following damage in the late Qing period, underline their resilience and enduring cultural significance (A. Zhang 2018; Zhao 2023).

Semiotically, Pailou symbolizes a hierarchical respect for education and the propagation of Confucian values. Their alignment and inscriptions reinforce their roles in Beijing's cultural and political narratives, positioning them as markers of historical continuity and cultural authority.

4.1.4. Pailou in Beihai park

Beihai Park, an integral part of the Qing Dynasty imperial gardens, houses four prominent Pailou: Xiaoxitian Glazed Pailou, Huazangjie Glazed Pailou, Zhishan Bridge Zhizhu Pailou, and Zhizhu Hall Four Pailou. These structures, constructed primarily during Emperor Qianlong's reign, encapsulated the Qing era's architectural and artistic achievements while reinforcing the park's ceremonial and cultural significance (Figure 12).

Strategically positioned along the park's north-south axis, Xiaoxitian Glazed Pailou celebrates Buddhist ideals, symbolizing the sacred Pure Land in Buddhist cosmology. Constructed in 1771 to commemorate Emperor Qianlong's mother's 60th birthday, its vibrant tiles and intricate carvings highlight spiritual sanctity and imperial devotion (Figure 13). Similarly, the Huazangjie Glazed Pailou at the park's northern boundary reflects the flourishing of Buddhist traditions under imperial patronage (Fang 2009; Wu and Xu 2022) (Figure 14).

The Zhishan Bridge Zhizhu Pailou and Zhizhu Hall Four Pailou create spatial coherence by defining



Figure 12. Locating Pailou in Beihai Park on Google Map.

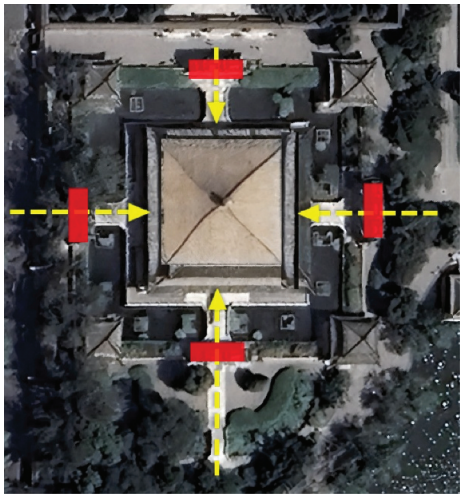


Figure 13. Locating Xiaoxitian Glazed Pailou(4) in Beihai Park on Google Map.

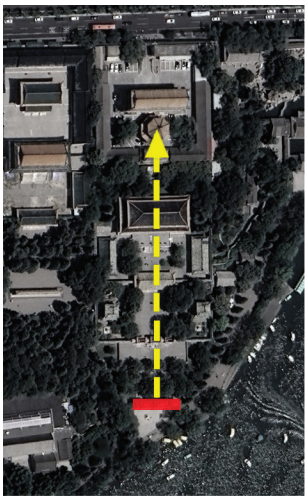


Figure 14. Locating Huazangjie Glazed Pailou on Google Map.

ceremonial axes that align with ritualistic practices (Ren 2007). Their designs emphasize a balance between natural landscapes and architectural structures, reinforcing both visual and spatial harmony within the park (Figure 15).

Symbolically, Pailou serves as a cultural landmark that integrates spatial, ceremonial, and aesthetic functions. Their architectural details, including mythological motifs and vibrant glazed tiles, enhanced the park's visual landscape while embedding the Qing ideals of governance and spirituality.

4.1.5. Pailou in the summer palace

The Summer Palace, constructed between 1750 and 1764, represents a quintessential example of the Qing imperial gardens. Among the original 41 Pailou, 15 remain (Pei and Yu 2023), strategically located at key ceremonial and scenic sites. These structures articulate the palace's dual role as a political and spiritual hub (Figure 16).

Hanxu Pailou, located at the eastern end of Beijing's central axis, marks the starting point of the celebrations and blessings depicted in the first volume of the *"Birthday Celebration for the Empress Dowager Chongqing."* Serving as a ceremonial entrance in a spatial sequence, this Pailou is closely aligned with the ceremonial functions of the central axis. Furthermore, along the same axis, Renshoumen Pailou enhanced the alignment of key architectural elements, demonstrating the unity of imperial authority and ritualistic order (Figure 17).

Yunhui Yuyu Pailou is situated on the northern bank of Kunming Lake, at the southern end of Longevity Hill. Its axial layout and architectural form embody the concept of "yin-yang balance" in Feng Shui, reflecting the philosophical principles of traditional spatial planning. By connecting major landmarks such as the Tower of Buddhist Incense and the Hall of the Sea of Wisdom, this Pailou not only illustrates the harmony of axial architecture but also symbolizes the transition from secular governance to spiritual enlightenment (Figures 1, 18, and 19).

At the northern end of Longevity Hill stands the Cifu Pailou, the entrance to the "Xu Mi Ling Jing"

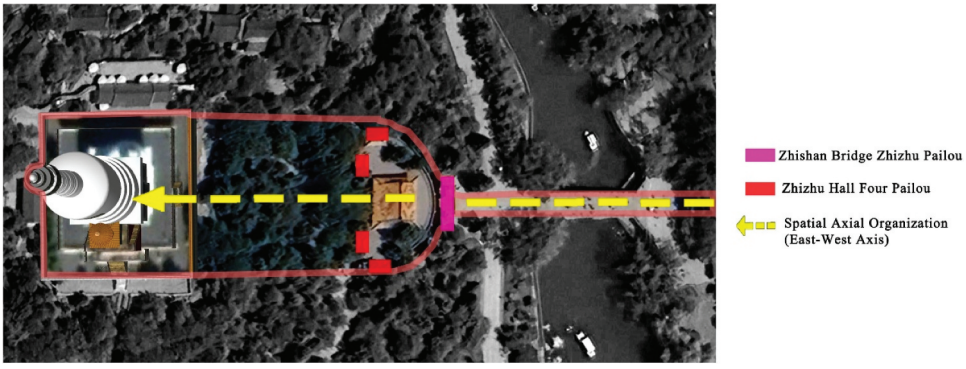


Figure 15. Zhishan Bridge Zhizhu Pailou and Zhizhu Hall Four Pailou on Qionghua Island.

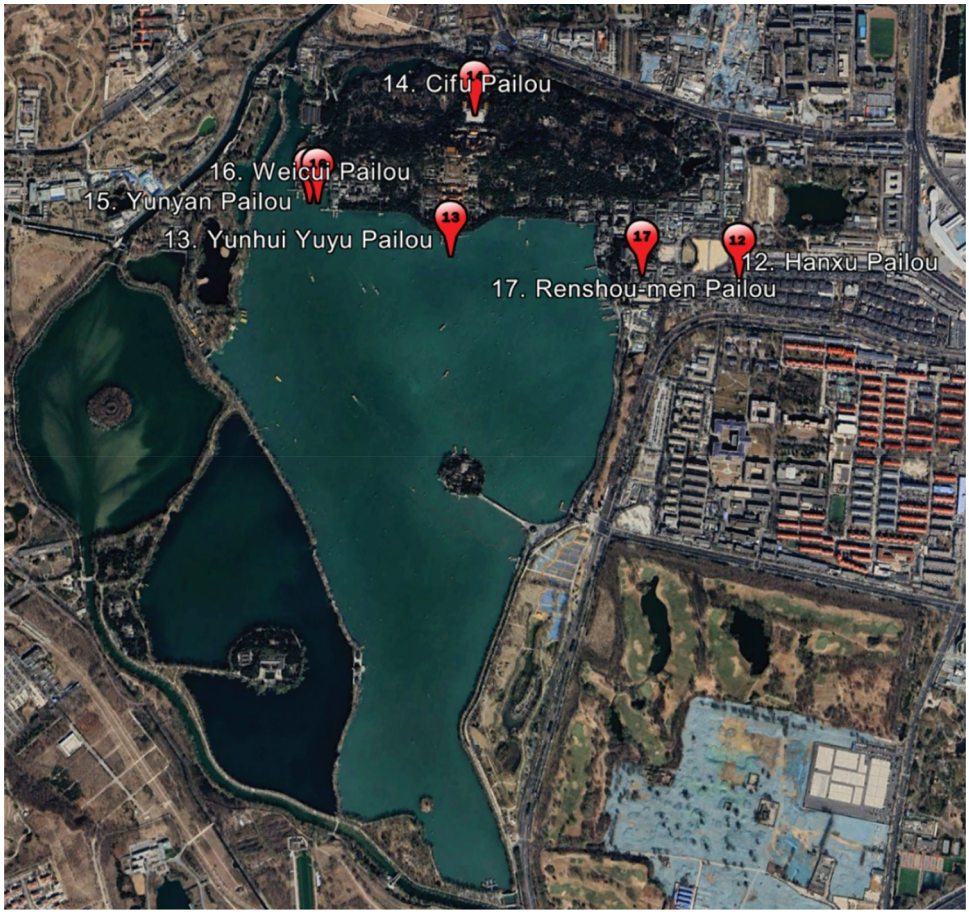


Figure 16. Locating of Pailou in the Summer Palace on Google map.

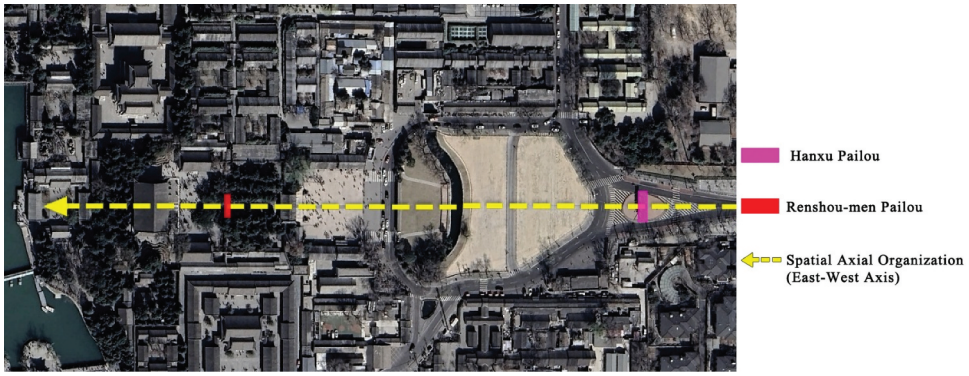


Figure 17. Hanxu Pailou and Renshou-men Pailou.

(The Sumeru Spiritual Realm). Together with Yunhui Yuyu Pailou, it forms a "yin-yang symmetry," representing the two poles of the axis. This design aligns with the cosmological principles of Chinese Feng Shui and the concept of "Tai Chi generates Two Forces" from the I Ching (Book of Changes) (Zhang 2021). This design further reinforces the symbolic significance of spatial sequences. The southern incline, embodying yang characteristics, and the northern slope, representing yin qualities, work in tandem to create a graduated and layered route. This design not only showcases the precise application of Feng Shui principles in spatial arrangement but also bolsters the ceremonial and symbolic cohesion of the overall structure.

Situated on opposite sides of the Xingqiao Bridge, the Yunyan and Weicui Pailou contributed to the palace's spatial cadence by blending natural and artificial components (Zhang 2015) (Figure 20). The Renshou-men Pailou, meanwhile, marked the division between areas designated for ceremonies and administration, underscoring the imperial notions of harmony and longevity.

In aggregate, these Pailou serve as a manifestation of Qing-era principles concerning governance, artistic sensibilities, and cultural fusion. Strategically placed



Figure 18. Cifu Pailou and Yunhui Yuyu Pailou.



Figure 19. Yunhui Yuyu Pailou at the front of the central.



Figure 20. Yunyan Pailou and Weicui Pailou.

alongside and filled with symbolic motifs, their placements within the palace reinforced the architectural narrative, while the sealing of the palace served to reflect the importance of the palace as a reflection of Qing imperial values.

4.1.6. Lingxing-men Paifang in the temple of heaven

Lingxing-men, on the central axis of the Circular Mound Altar at the Temple of Heaven, has deep historical and cosmological meaning. Constructed during the Ming Dynasty and continuously utilized throughout the Qing Dynasty, it served as an entrance to the sacrificial site, delineating the boundary between sacred and secular spaces. It marked the transition into the sacred realm, clearly defining the roles and positions of the participants and reflecting a strict hierarchical order. Ritual officials guided the emperor through the Lingxing-men to specific worship positions, organizing court officials to line up on the steps to ensure the orderly conduct of sacrificial ceremonies (Zhang 2011). The Lingxing-men not only symbolize the celestial gateway, resonating with the sanctity of the sacrificial site, but also reinforce the authority and religious significance of the rituals. This structure played an indispensable role in the intricate and solemn heaven-worship ceremonies of the Ming

and Qing Dynasties, embodying the rigorous regulations of ancient rites concerning imperial power and hierarchical order while also reflecting the profound connection between these rituals and cosmological beliefs.

Lingxing-men Pifang's minimalist design, featuring two pillars and one span without a roof, underscores the space's sanctity. Its alignment reflects the ancient cosmological principle of "Round Heaven, Square Earth," symbolizing the unity of the universe. These 24 doors correspond to the 24 solar terms in the Chinese agricultural calendar, which integrates celestial rhythms with terrestrial practices.

Adorned with carvings inspired by I Ching, Lixing-men embody harmony between humanity and nature. From a planar overhead view on Google Maps, the design of the Lingxing-men at the Circular Mound Altar reveals a layout of an inner circle and outer square, reinforcing its role as a ceremonial symbol by integrating its ritual function with cosmic beliefs that illustrated the integration of natural philosophy into architectural and ritual traditions by encapsulating the emperor's divine role in maintaining cosmic harmony (Figure 21).

4.2. Findings of three configurations and cultural symbolism

Based on the research methodology, this study used the Landmark Spatial Indexing (LSI) framework and CIDOC CRM to systematically examine the spatial, temporal, and symbolic dimensions of 18 official Pailou in Beijing. Drawing from comprehensive literature reviews, digital mapping tools (e.g., Google Maps), and field investigations, the findings categorized Pailou into three spatial configurations: point, line, and enclosure. The spatial arrangements and cultural functions not only further clarify the order of the classification of Pailou, but also explain in depth their more profound meaning within the historical and cultural context of Beijing.

Building on the CIDOC CRM semantic model, the research maps validate the core codes, categories, and themes of the 18 LSI Pailou. Point-configured Pailou emphasizes "monumental landmarks" and central societal symbols; Line-configured Pailou underscores "axial connectivity" and the guidance of movement; and Enclosure-configured Pailou focuses on the "separation, transition, and preservation" of sacred and royal spaces. Through this multidimensional classification and validation, this research provides a clearer understanding of the multifaceted roles that Pailou plays in ritual spaces, cultural symbolism, and the construction of social order. Additionally, employing the LSI's geographic visualization method, this study Lingxing-men the dynamic connections of Pailou within urban ceremonial and functional spaces, further affirming their historical and cultural symbolic value (Table 4).

4.2.1. Point-configured Pailou: anchoring axial hierarchies

Point-configured Pailou serve as monumental "landmarks" and "ceremonial gateways," strategically anchoring ceremonial axes within Beijing's urban structure. Architecturally diverse examples include the imposing "six-pillar, five-bay, five-roof" Zhengyang Bridge Five Pailou, symbolizing imperial authority; simpler "two-pillar, one-bay, one-roof" structures delineating transitional boundaries; the Guozijian Glazed Pailou, embodying Confucian cultural traditions; and the Hanxu Pailou at the Summer Palace, structuring royal ceremonial sequences. Moreover, the Huazangjie Glazed Pailou combines Buddhism with imperial symbolism, signifying a great cultural transformation. Spatial linkages along ceremonial

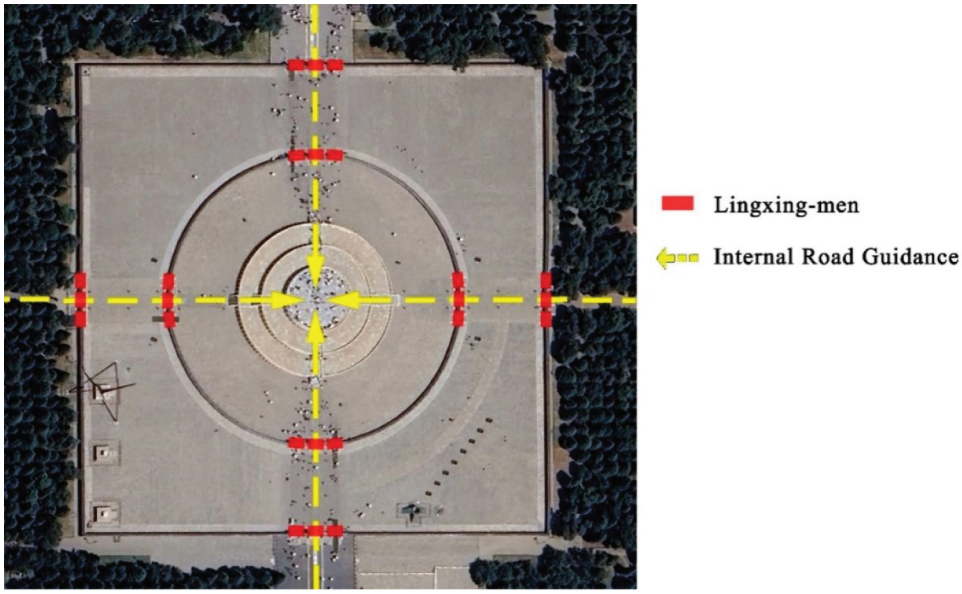


Figure 21. Plan of the Lingxing-men at the Circular Mound Altar of the Temple of Heaven.

Table 4. Spatial Configuration Attributes and Symbolism of Beijing Official Pailou based on CIDOC E-Class Code.

Configurations	Name of Pailou	LSI	CIDOC E-Class Code	Categories	Themes	Spatial Configurations Attributes	Symbolism
Point (8)	• Zhengyang Bridge Five Pailou, • Guozijian Glazed Pailou, • Huazangjie Glazed Pailou, • Zhishan Bridge Zhizhu Pailou, • Hanxu Pailou, • Yunhui Yuyu Pailou, • Cifu Pailou, • Renshou-men Pailou	1， 5， 9， 10， 12， 13， 14， 17	E53 Placee; 52 Time-span; E90 Symbolic Object; E92 Spacetime Volume; E22 Human-made Object; E36 Visual Item	Spatial axial organization; Cultural symbolism; Architectural craftsmanship and aesthetics; Ceremonial and hierarchical integration; Boundary and transitional definition	Axis and Hierarchical Structure; Symbolism and Ideological Values; Craft-meaning Integration; Spatial Transition and Unity.	Landmark Nodes; Gateway Markers	Authority, cultural enlightenment, and blending of Sacred and secular spaces.
Line (3)	• Guozijian Pailou(2) • Chengxian Street Pailou(2) • Weicui Pailou and Yunyan Pailou(2)	6， 7， 15–16		Spatial Organization; Cultural Symbolism; Architectural Details; Natural and Spatial Harmony	Cultural and Spatial Unity; Artistic and Ethical Balance.	Spatial Connectivity; Directional Guidance	Confucian ideals, hierarchical order, and harmony between nature and architecture.
Enclosure (4)	• Yonghe Temple Pailou(3), • Xiaoxitian Glazed Pailou(4), • Zhizhu Hall Four Pailou(4), • Lingxing-men Paifang (24)	2–4， 8， 11， 18		Boundary Definition; Symbolic Craftsmanship; Historical and Cultural Narratives	Boundary Definition Spiritual and Cosmological Ideals; Creating Ceremonial Spaces	Boundary Definition; Spatial Containment	Imperial dignity, buddhist values, and cosmological principles.

pathways of the Zhishan Bridge and Zhizhu Pailou, Yunhui Yuyu Pailou and Cifu Pailou are able to fuse spiritual and secular realms through the use of feng shui. Semantic analysis utilizing CIDOC CRM highlights their historical context (E52), spatial significance (E53), symbolic meaning (E90, E36), architectural sophistication (E22), and ceremonial adaptability (E92), collectively reinforcing their central roles as "Landmark Nodes" and "Gateway Markers," bridging secular and spiritual domains.

4.2.2. Line-configured Pailou: connecting spaces and continuity of order

Line-configured Pailou significantly enhance "Spatial Connectivity" and provide essential "Directional Guidance," facilitating ceremonial continuity along urban pathways. Architecturally balanced, these typically adopt configurations such as "two-pillar, three-bay, three-roof" or "four-pillar, three-bay, three-roof." Paired Pailou at Guozijian and Chengxian Street are specific cases of endpoints of an academic and ceremonial axis based on Confucian principles, and Weicui and Yunyan Pailou at the Summer Palace are specific cases of harmonious integration of natural and artificial landscapes. These structures are symbolically related to Confucian concepts on hierarchical harmony, spatial coherence, and structured order. Through CIDOC CRM analysis, their strategic spatial placements (E53), historical relevance (E52), symbolic expressions (E90, E36), architectural craftsmanship (E22), as well as ceremonial flexibility (E92) are explained. These attributes reflect in collective the critical role which they play in inventing synchronized space networks of Beijing and keeping cultural continuity.

4.2.3. Enclosure-configured Pailou: defining sacred spaces and ceremonial order

Enclosure-configured Pailou define sacred precincts and reinforce ceremonial order through explicit "Boundary Definition" and "Spatial Containment." Architecturally varied, examples include elaborate "four-pillar, three-bay, nine-roof" structures symbolizing imperial grandeur, and simpler "two-pillar, one-bay" forms serving transitional functions. Yonghe Temple's multi gate arrangement is specifically about the transition from secular to sacred realms, and Xiaoxitian Glazed Pailou in Beihai Park is about integrating Buddhist principles into imperial contexts. Similarly, Lingxing-men Pailou at the Temple of Heaven marks sacred imperial ceremonial boundaries, reinforcing cosmological ideas of "Round Heaven, Square Earth." The Four Pailou of Zhizhu Hall also demonstrates ceremonial spatial delineation that links royal authority with spiritual devotion. Their historical framing (E52), their important spatial positioning (E53), the symbolic cultural content (E90, E36), the degree of elaboration of their architectural detailing (E22) and their symbolic versatility in ceremony (E92) are further clarified through a CIDOC CRM semantic analysis. As a result, these enclosure configured structures systematically articulate sacred spatial framework, which is designed to enhance ceremonial coherence and symbolic hierarchies in the historical Beijing.

4.3. Findings on the spatial and cultural narratives of Beijing's Pailou

Beijing's Pailou spatially reflect diverse roles in ceremonial order, social hierarchy, and cultural heritage. Specifically, categorized into point, line, and enclosure configurations, these structures embody symbolic prominence, functional coherence, and cultural narratives transmitted across generations.

Firstly, point-configured Pailou anchor ceremonial axes and routes, serving as prominent symbolic landmarks. Additionally, they foster social interaction and reinforce imperial authority. Secondly, line-configured structures link significant urban spaces and ceremonial routes, guiding movement while enabling cultural reflection and embodying Confucian spatial harmony. Lastly, enclosure-configured Pailou clearly define ritual boundaries, demarcating sacred precincts from secular areas, exemplified notably by structures such as Lingxing-men in the Temple of Heaven.

Furthermore, CIDOC CRM semantic mapping elucidates their integrated spatial-symbolic roles. Specifically, E53 Place and E92 Spacetime Volume highlight spatial-temporal functions as ritual nodes, while E90 Symbolic Object and E36 Visual Item emphasize visual symbolism within architecture. Additionally, Landmark Spatial Indexing (LSI) further reveals adaptive spatial distributions: point structures anchor ceremonial spaces, linear structures connect routes, and enclosure structures clearly demarcate sacred areas, collectively affirming their adaptability and contemporary relevance.

Overall, Pailou exemplify sophisticated spatial-cultural expressions prevalent during Ming and Qing traditions. Their symbolic, cognitive, and spatial complexities embody core cultural themes – ritual governance, hierarchy, and identity – highlighting their contemporary potential in interdisciplinary research, digital preservation, and cultural tourism. By empirically linking spatial semiotics, cognition, and heritage conservation theories, this study enriches theoretical discourse. Consequently, it aligns closely with foundational spatial frameworks such as Lynch's landmark theory (Lynch 1960), thus expanding interdisciplinary dialogue and enhancing practical conservation strategies.

4.4. Discussing global heritage conservation challenges and implications

Heritage conservation challenges, including rapid urbanization, tourism pressures, and inadequate management, have become widespread globally. In Asia, rapid urban expansion has resulted in significant heritage loss in cities like Surat in India, Lahore in Pakistan, and Ho Chi Minh City in Vietnam (Kashihara, Nguyen, and Suzuki 2022; Udeaja et al. 2020; Younus 2022). Although China and Japan have established heritage frameworks aligned with ICOMOS guidelines, interpretations of "authenticity" in wooden architectural heritage conservation still differ between the two countries (Jing, Wang, and Masui 2023). Malaysia similarly faces increasing developmental pressures, highlighting the need for more systematic heritage protection strategies (Abdullah, Ling, and Abdul Rahman 2021).

In Europe, rising tourism has created tensions between heritage preservation and local community use, as demonstrated by access restrictions in Barcelona's Park Güell (Mazzamuto and Picone 2022). Moreover, the United Kingdom faces ongoing debates regarding post-war modernist heritage, complicating preservation efforts despite growing international recognition (Aelbrecht 2021). African nations such as Nigeria and Ethiopia confront challenges like insufficient funding and limited community participation, contributing to continuous heritage deterioration (Mekonnen, Bires, and Berhanu 2022; Okpalanozie and Adetunji 2021). Australia has experimented with intelligent monitoring technologies aimed at reducing maintenance expenses, though these remain largely experimental (Cruz et al. 2021).

While specific contexts vary, these examples collectively illustrate common global challenges in heritage conservation. The integrated analytical framework proposed by this study (combining Landmark Spatial Indexing, CIDOC CRM, and Peircean Semiotics) provides a systematic approach for analyzing and interpreting spatial-symbolic dimensions of urban heritage. Although further empirical validation is necessary, this framework may offer useful insights for urban planners seeking to balance heritage authenticity and cultural significance with contemporary urban development demands.

5. Conclusion

This research integrated Landmark Spatial Indexing (LSI), the CIDOC CRM framework, and Peircean semiotics to systematically analyze the spatial configurations and symbolic significance of Beijing's official Pailou. By categorizing 18 LSI Pailou into three configurations – point, line, and enclosure – this study reveals their dual role as spatial markers and cultural transmitters. These findings trace their origins to ancient astronomical observations centered on "Zhong" (the center), Daoist Taiji yin-yang principles, and the spatiotemporal systems of cardinal directions and the 24 solar terms.

Each spatial configuration contributes uniquely to urban heritage: Point-configured Pailou function primarily as symbolic landmarks, asserting imperial authority and cultural prominence within urban contexts. Line-configured Pailou serve as wayfinding elements, guiding ceremonial routes and embodying Confucian ideals of harmony and spatial continuity. Enclosure-configured Pailou distinctly demarcate sacred precincts from secular spaces, symbolically mediating cosmological order and imperial ideology. Collectively, these spatial configurations structured social hierarchies, reinforced cultural transmission, and facilitated ceremonial activities, underscoring their significance within Beijing's historical urban fabric.

Integrating LSI with CIDOC CRM establishes a structured semantic framework that systematically encodes spatial attributes (E53 Place, E92 Spacetime Volume) and symbolic meanings (E90 Symbolic Object, E36 Visual Item). Employing accessible digital tools, such as Google Earth Pro, further demonstrates practical advantages for heritage documentation, precise mapping, and global accessibility. However, this study acknowledges certain limitations, including potential regional and temporal generalizations resulting from analyzing only 18 Pailou across six locations. Moreover, qualitative methodologies inherently constrain advanced spatial-statistical validation, and digital mapping tools may introduce biases related to data resolution, georeferencing accuracy, and manual interpretation. Future studies could address these limitations by integrating GIS-based hotspot analysis and multi-scale spatial clustering techniques, proven effective in capturing spatial heterogeneity and socio-cultural patterns (Majumder et al. 2023; Roy and Chowdhury 2023; Roy et al. 2024). Such methods would enhance analytical rigor and complement symbolic-spatial interpretations.

Furthermore, comparative analyses with landmark structures from other cultures could enrich understanding of the distinctive spatial-symbolic features of Beijing's Pailou. Japanese Torii gates, for instance, similarly symbolize transitions from secular to sacred realms but typically emphasize linear progression without intricate enclosure elements. European triumphal arches primarily represent political authority and historical commemoration, marking urban nodes or ceremonial axes akin to Point and Line Pailou but generally lacking explicit sacred enclosures. In contrast, Indian gopurams emphasize vertical enclosure symbolism, marking hierarchical thresholds into sacred

precincts, closely paralleling yet distinctly different from the enclosure configurations of Pailou. These cross-cultural insights underscore the unique integration of Point, Line, and Enclosure configurations in Beijing's official Pailou and suggest their broader applicability as universal spatial-symbolic mediators.

Practically, this research significantly contributes to modern heritage preservation strategies, particularly in high-density urban environments. Recognizing the distinct spatial-symbolic roles of landmarks can inform targeted conservation efforts – protecting individual landmark nodes (point), ceremonial routes (line), and clearly defined sacred precincts (enclosure) – thus maintaining urban historical continuity, enhancing heritage tourism, and informing cultural policymaking amid rapid urbanization. Moreover, the spatial classification framework developed here may be adapted to analyze other architectural typologies, such as temples, city gates, or historic districts, offering analytical versatility for broader urban heritage research.

In conclusion, Beijing's official Pailou exemplify an intricate synthesis of imperial authority, religious philosophy, and cultural identity. By deepening existing theories of spatial semiotics and heritage conservation, this research offers an integrated analytical approach that bridges theoretical discourse with practical urban heritage conservation, providing meaningful insights into contemporary cultural policy and urban planning practices. Future research incorporating advanced analytical techniques – such as machine learning for automated landmark classification, immersive Virtual Reality (VR) for public engagement, or regional comparative studies – would further expand the theoretical depth and practical applications of this framework. Ultimately, understanding the spatial-symbolic roles of Pailou matters profoundly in an era of rapid urban transformation, as it not only preserves cultural identity amid modernization but also guides how cities can sustainably balance heritage conservation with contemporary urban development.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Author contributions

Yang Juan conceptualized the research framework, conducted data collection and analysis, and prepared the initial draft of the manuscript. Mohd Fabian Hasna provided supervision and guidance on the integration of semiotic theory and spatial indexing techniques and contributed significantly to the refinement of the manuscript. Nor Azlina Abu Bakar contributed to the methodological framework, ensured alignment with CIDOC CRM standards, and reviewed the manuscript critically for intellectual content. All authors reviewed and approved the final manuscript for submission.

Data availability statement

All relevant data supporting the findings of this study are included within the manuscript and its supplementary materials. Additional data, if required, can be made available upon reasonable request to the corresponding author.

Ethics approval

This study has been reviewed and approved by the Universiti Putra Malaysia Ethics Committee. JKEUPM Ref No.: JKEUPM-2024-281.

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