

RESEARCH ARTICLE

Open Access



Exploring visitors' visual perception along the spatial sequence in temple heritage spaces by quantitative GIS methods: a case study of the Daming Temple, Yangzhou City, China

Kai Zhou¹, Wenting Wu^{1*}, Tianjie Li¹ and Xiaoling Dai¹

Abstract

The Daming Temple, built during 457–464 C.E., is one of the developing ancient temple heritage spaces located in Yangzhou city, P. R. China. Over the past 60 years, variation in visitors' spatial perception along the tour routes in the temple has occurred. This research attempts to reveal the changes in visitors' visual perception along the spatial sequences at 3 different times (i.e., 1962, 1973 and 2022). A quantitative GIS-based method, which includes analysing the distribution of visitors' spatial preferences and spatial configuration, is proposed. Digital landscape tools and quantitative estimation methods are used, including mapping within Rhinoceros software, the kernel density estimation (KDE) method within ArcGIS software and spatial syntax analysis within DepthMap software. Extracted geodata from 500 photographs of the heritage space taken by volunteer visitors are analysed within the GIS environment. Values of the mean depth (MD) at both levels of visibility and accessibility are calculated within the visibility graph analysis (VGA) model. Comparisons between the visual preferences of the visitors and the spatial configuration along the spatial sequence are conducted. The results indicate that the spatial sequence has a significant impact on visitors' visual preferences and tour routes. The phenomenon of spatial sequence among dynamic temporal variations and the effects of narrative spaces along the spatial sequence are highlighted and explained, which reveal the relationship between visitors' geospatial preference and the spatial configuration of the temple. Some suggestions are put forwards for further studies on the revitalisation and management of East Asian ancient temple heritage spaces.

Keywords temple heritage space, visual preference, spatial sequence, spatial configuration, GIS

1 Introduction

1.1 Starting point of the research

Temple heritage sites in East Asia have often been changed over lengthy periods of time and may have been

severely damaged by war and poor conservation (Yan and Li 2023). Some attention has been given to both the conservation and sustainable development of temple heritage sites. The Daming Temple is a well-preserved cultural heritage site located in the city of Yangzhou, P. R. China (Zhou et al. 2023). The Daming Temple has become one of the most popular tourist attractions in Yangzhou city, ranking among the top 10 recommended attractions in the city according to major tourism websites in P.R. China; there have been many photographs of the site

*Correspondence:

Wenting Wu
wuwenting@zjut.edu.cn

¹ School of Design and Architecture, Zhejiang University of Technology, 288 Liuhe Rd, West Lake District, Hangzhou 310023, China

taken by visitors, some of which are extremely popular online (Wang 2016).

There are various factors that may affect visitors' preferences in heritage spaces, such as the tangible and intangible attributes of landscape elements, personal knowledge, and cultural background (Zhao et al. 2022; Vasconcelos et al. 2022). The spatial system of Chinese temple gardens often comprises landscape elements that contribute to the complexity and similarity of the structure with narrative spaces (Liu and Lu 2019; Lin et al. 2022); therefore, the design of the physical space often acts as a 'framework', blending the narrative contents and the spatial structure of the space together. It has been previously highlighted that the narrative effects of the spatial sequence can also influence visitors' behaviour and environmental cognition in landscape spaces (Nasar 1987; Wei et al. 2022). However, few studies have been conducted with the aim of explaining the mechanism of these narrative effects by specific spatial configurations. Thus, there is potential to analyse the relationship between visitors' spatial preference and spatial configuration using quantitative tools and methodologies; in turn, this method has the potential to be used as a quantitative-method-based approach for historical urban landscape (HUL) studies.

1.2 Literature review

1.2.1 Research on the Daming Temple

The Daming Temple (119.41°E, 32.42°N) was built during the 457–464 C.E. period. Monk Jianzhen (688–763 C.E.), who was the host of the temple, sailed east to Japan and built the Toshodai-ji Temple; this temple facilitated the development of Vinaya Buddhism, which is one school of Mahayana Buddhism. Historically, a variety of Buddhist schools, including Zen Buddhism, Vinaya Buddhism, Vajrayana Buddhism, and Sukhavati Buddhism, have established their monasteries and/or temple gardens within the Daming Temple grounds (Susumu 1974). The temple has been expanded on numerous occasions. During the Sui dynasty, Emperor Yang Jian built the Qiling Pagoda. During the Northern Song dynasties, several literati, e.g., Ouyang Xiu (1007–1072 C.E.) and Su Shi (1037–1101 C.E.), contributed to the design and construction of the temple. During the Qing Dynasty, Wang Yinggeng (1680–1742 C.E.), a famous merchant, built the western garden. The layout of the Daming Temple did not significantly vary from the late Qing Dynasty until 1962 (Guo 2015). However, the design and construction of the Jianzhen Memorial Hall adjacent to the temple, built from 1962 to 1973, drastically affected the layout of the temple garden. Since the 1990s, with the expansion of the eastern district and the western garden, the Daming Temple has undergone variations in layout (Zhou et al.

2023). However, only a few studies (Wang 2016; Zhou et al. 2023) have been conducted on the history, culture, architecture, design methodology and management of the Daming Temple. One such existing study (Zhou et al. 2023) focuses on providing qualitative spatio-temporal analysis of temple heritage spaces. However, there is still a lack of quantitative GIS methods available with which to assess the impact of the spatial sequence of the ancient temple on the visual perception of tourists.

1.2.2 Research on photograph-based POE

Post-occupancy evaluation (POE) is an estimation method employed in some spatial planning and design studies (Breadsell et al. 2019). For instance, the POE of an ancient temple in Quanzhou city, China, was conducted based on the perspective of visitors; in this study, five factors affecting the perceptions of visitors were identified, including spatial structure and visual perceptual characteristics (Zhao et al. 2022). However, the numerous limitations of POE suggest that an integrated use of POE and geospatial technologies is adaptable (Chen et al. 2023). Existing research has suggested that the spatio-temporal characteristics of tourism attractions may influence visitors' perceptions, while photographs may reflect visitors' preferred behaviours (Yan et al. 2023). Thus, visitors' perceptions along spatial sequences in the temple can be revealed by taking a quantitative approach to extracting information from photos taken by visitors. Although photo-related assessments have been applied in studies for large-scale geographical research, there is still a lack of research using appropriate methods for landscape-related disciplines (Edwards et al. 2019). However, there is also potential for quantitative studies to use extracted geodata from photographs taken by visitors in small-scale heritage spaces.

1.2.3 Research on the space syntax method for heritage

Several quantitative techniques and methods have been applied in spatial studies by landscape architects, e.g., the Geodesign tool, spatial syntax, building information modelling (BIM), microclimate simulation tools, etc. (Li et al. 2022; Mei et al. 2020). Space syntax is a widely used quantitative method used to represent spatial patterns that was originally applied in various fields, e.g., urban planning, architecture, and archaeology. In recent decades, spatial syntax has gradually emerged as a possible method for studying diverse types of small-scale spaces by landscape architects, e.g., rural settlement landscapes (Xu et al. 2023), cultural heritage sites (Zal-eckis et al. 2022), Iranian traditional courtyards (Zolf-agarkhani & Ostwald 2021), and Chinese private gardens (Yu et al. 2016).

Some types of spatial syntax models have been applied to assess the organisation of heritage spaces and the internal characteristics of their layout. For example, regarding the spatial outcomes of a Theravada Buddhism heritage temple located in Chiang Saen, Thailand, both spatial and social systems were found to be arranged, with in-between negotiation and variation (Karmilah and Magfiroh 2018; Moonkham and Duff 2021). Spatial syntax models have been adapted to reveal the spatial configuration of ancient temple heritage sites in southern Levant (Susnow, 2021; Susnow and Goshen, 2021). A spatial syntax model has also been developed in combination with daylight brightness simulations to assess configurations and suggest ideal itineraries for the restoration of Ottoman heritage sites in Algeria (Saraoui et al, 2022). These previous studies provide an in-depth comprehension of the characteristics and functionalities of religious culture; however, most of them do not consider visitors' environmental perceptions, which are vital for guiding the conservation and sustainability of ancient temple heritage spaces.

For heritage conservation and management, several studies (Hegazi et al. 2022; Zaleckis et al. 2022) on the preliminary application of spatial syntax to assess the socio-spatial vulnerability of heritage buildings in some historic areas have helped heritage managers to better understand the structure of heritage spaces and how space influences visitor behaviour within them. Some empirical UHL-related studies have also identified the spatial parameters of networks in heritage spaces that can influence the valorisation of Buddhist heritage artefacts and enable cultural mobility (Karmilah and Magfiroh 2018; Arbara 2022). However, to date, few quantitative studies have presented a feasible methodology for tourism managers, landscape architects and tourism geographers to assess the relationship between the spatial configuration of ancient temple heritage spaces, landscape outcomes and the behavioural preferences of visitors.

1.2.4 Innovations of the study

It is noteworthy that multiple methodologies and tools, including photograph-based POE and space syntax, have been primarily applied in a few studies related to heritage archaeology and heritage revitalisation. Using images as a data source for large spatial disciplines such as urban planning and geography is different from using images as a data source for small-scale landscape spaces. Therefore, it is possible to use a new method to extract the geographic information from *in-situ* photographs taken by volunteers as more authentic information. This research aims to present a practical integrated approach that is able to not only extract tourists' geographic information

and visual preferences from tourists' photographs but also reveal spatio-temporal relationships between the pattern of tourists' preferences and changes in tourists' spatial perception along the tour routes in typical temple heritage spaces. By applying integrated methods for revealing the spatial patterns of tourists' preferences, i.e., photo-based geodata extraction and the visibility graph analysis (VGA) model, the changes in tourists' spatial perception along the main tour routes can be revealed, which may guide the further optimisation of heritage spaces with sustainable revitalisation and tourism management.

Built heritage sites with intricate spatial arrangements typically offer visitors an exceptional spatial encounter through their spatial sequences, which should be fully consideration in their spatial reinvigoration and management (Geng et al. 2022; Zhou et al. 2023). A narrative spatial sequence will prompt tourists to explore the spatial narrative process in the development of cultural tourism in East Asian temple heritage sites (Moon 2022). Spatial syntax tools have been suggested as a means of exploring the spatial qualities of heritage management. This approach poses a critique of the use of stylistic periodisation in defining heritage sites, instead promoting an understanding of the role of spatial and temporal configurations in the production and reproduction of events (Zaninović et al. 2018; Palaiologou and Griffiths 2019).

The specific contribution of a temple can be affected by its complex spatio-temporal variations. As a consequence, visitors' visual perception of the area's spatial sequence can be dramatically altered, which is evident during the spatial narrative process. The author intends to reveal visitors' spatial perception among the dynamic temporal changes during different periods of the Daming Temple's spatial variations and the narrative effects of the spaces located along the spatial sequences. These narrative effects can be reflected in multiple spatial characteristics, including visitors' perception of enclosure/openness, preference, visibility/accessibility, etc. The methodologies employed in this research will assist in the design and management of the distinctive cultural and spatial features of this Chinese temple space. Our findings will be helpful for offering suitable recommendations for enhancing spatial functionality and landscape design, while also considering spatial sequences through their narrative processes.

2 Materials and methods

2.1 Framework and data preparation

The research framework of this study is shown in Fig. 1. A quantitative method is proposed to reveal the changes in visitors' spatial perception along common tour routes in a temple heritage space, namely, integrating

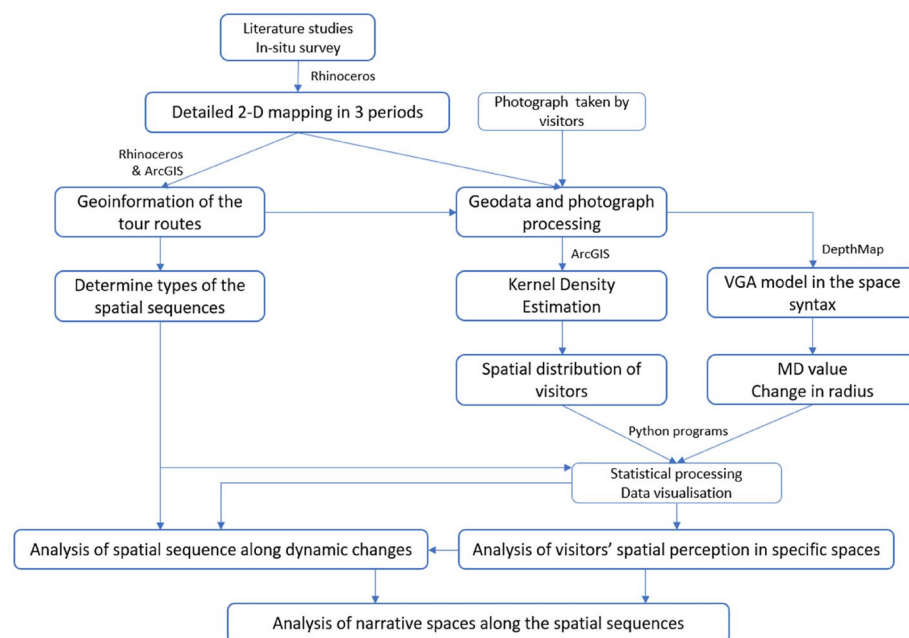


Fig. 1 The research framework. Methodologies, software, and other tools utilised in this research are presented in steps. Digital landscape tools and quantitative estimation methods are used, including mapping within RhinoCeros software, the kernel density estimation (KDE) method within ArcGIS software and spatial syntax analysis within DepthMap software (Source: the authors)

photograph-based visitors' visual preference analysis and VGA-based analysis of spatial configuration in a typical ancient temple heritage space. We focus on exploring the spatial sequence of dynamic changes and explaining visitors' spatial perception at the site, which will be of help for narrative spaces located along the spatial sequences. Some digital landscape tools and quantitative estimation methods are used in the research, including mapping within RhinoCeros 7 software (a digital and parametric modelling software developed by Robert McNeel & Associates, Seattle, WA, USA), the kernel density estimation method within ArcGIS 10.2 software (a software developed by Environmental Systems Research Institute, Inc., California, USA) and spatial syntax analysis within DepthMap software (a software developed by University College, London, UK).

According to historical records, the Daming Temple has undergone two major expansions in the past 60 years. Between 1962 and 1973, its layout changed slightly with the construction of the new Jianzhen Memorial Hall. After the 1990s, the successive expansion of the temple in the eastern district and the renovation of the western garden resulted in dramatic changes to the spatial layout, with gradual changes made to the tour route (Zhou et al. 2023). In this study, the spatial layout of the scenic area before and after the abovementioned expansions is the main object of study; thus, three periods were selected for research.

The *in-situ* survey and mapping used herein are based on maps drawn by scholars at Tongji University in the 1960s and 1970s and accurate mapping data provided by the Cultural and Publicity Department of Daming Temple. An *in-situ* survey was also conducted to determine the current layout of the temple's cultural heritage areas; the resulting maps (Fig. 2) were processed into digital maps using RhinoCeros 7. Detailed 2-D maps of the Daming Temple in the three different periods chosen for the current study are represented in Fig. 3.

The three periods of change had an impact on the use of the space. The main purposes and original designs of the Pingshan Hall buildings, the western garden and the Buddhist functional areas have been maintained since their construction. However, the characteristics of the site have been affected by the addition of the Jianzhen Memorial Hall (post-1970s conversion area) and the extension of the eastern district (post-1980s conversion area). These areas were designed and built specifically for Buddhist visitors from various schools and those interested in Buddhist culture.

Notably, since the 1990s, the temple's financial income has increased rapidly due to its tourism development. Since the 2010s, the temple's income has been able to cover the necessary major maintenance. The number of visitors to the temple has increased, including Buddhist visitors and non-Buddhist tourists. Most visitors come to the temple for the first time during a tour. The effects of

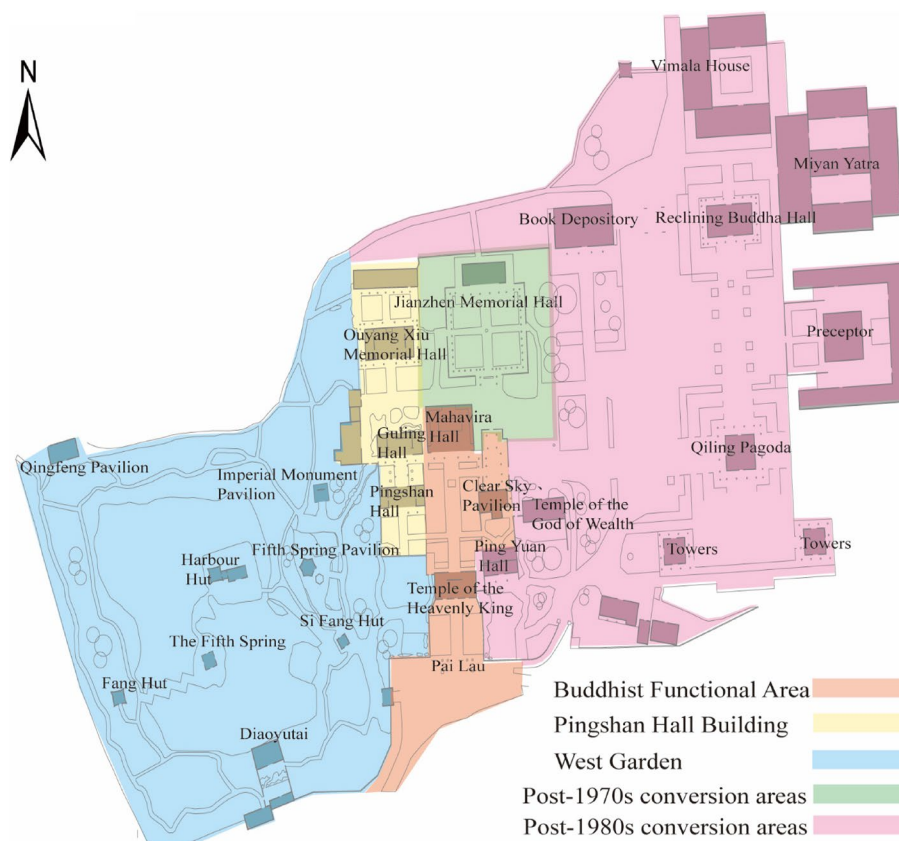


Fig. 2 Layout mapping of the Daming Temple in 2022. The figure is taken from Zhou et al. (2023). The 2-D plan map is drawn on the basis of the accurate mapping data provided by the Cultural and Publicity Department of Daming Temple and the *in-situ* survey (Source: the authors)

the narrative space can have conspicuous effects on the visual perceptions of the visitors, which can lead to variations in the tour routes and duration of visitors' stay at the temple. Therefore, to improve the temple's spatial planning and landscape design by considering the narrative process that presently occurs in the temple, it is important to pay attention to visitors' visual perceptions that occur along the spatial sequence of the temple's heritage spaces.

The characteristics of 500 valid typical photographs taken by volunteer visitors with their mobile phones were extracted to further investigate the pattern of visitors' visual preferences; a sample of 500 photographs is suitable for both volunteers to take and for GIS software to process. Most of the visitors were first-time visitors of the temple. Samples of these photographs are presented in Fig. 4. GPS modules on the visitors' mobile phones (geodetic datum: WGS84, sampling time: 2022) synchronously recorded the geospatial coordinates of the locations where the photographs were taken. The photographs were obtained by the following method. First, the central point of each photograph (point A) was selected and extended to the target (point D). Second, based on

the projection of 2 spatial points and 1 spatial line, the observation point O and the sight L of the photographs were obtained. Finally, by geoinformatics calculations, we determined each visitor's preferred point of view (Fig. 5). Notably, the limitation of this method is that the researcher should be quite familiar with the *in-situ* conditions of the study site. This method is therefore suitable for small- and medium-sized heritage spaces because there are often plenty of homogeneous elements in the photos of small-scale gardens, which makes it difficult for image identification programmes to recognise them automatically.

2.2 Data-processing methods

The distribution map of visitors' spatial preferences in the study was calculated by kernel density estimation (KDE); this is a commonly applicable method for generating a representation of local density estimates from 2-D points, which can be applied to portray the spatial density characteristics and distribution trends of objects. KDE can effectively reflect the influence of the nucleus on the surroundings. In this study, KDE was used to analyse visitors' distribution to determine their spatial preferences.

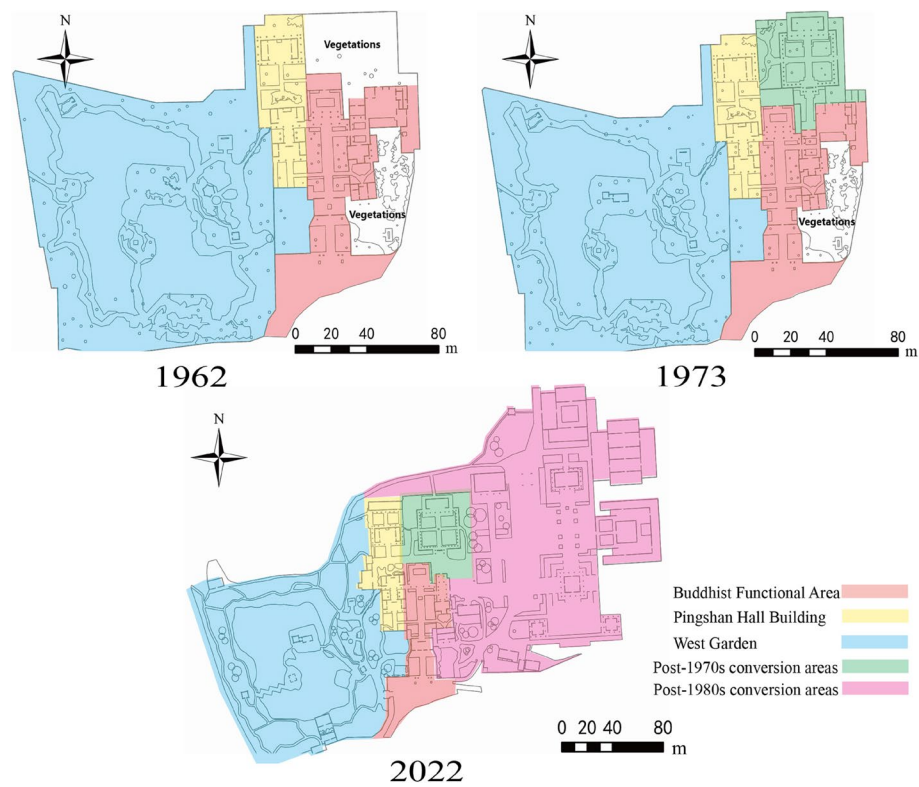


Fig. 3 The 2-D maps of the Daming Temple in three different periods. The figure is taken from Zhou et al. (2023). The author refers to two historical maps drawn by scholar Congzhou Chen (1918–2000 C.E.) of Tongji University in the 1960s and the 1970s, as well as maps drawn during the *in-situ* survey conducted in 2022 by the Cultural Publicity Department of the Daming Temple, Jiangsu Province (Source: the authors)



Fig. 4 12 samples of typical photographs utilised in the research taken by volunteer visitors. The names of the scenic spots are presented below the samples (Source: the authors)

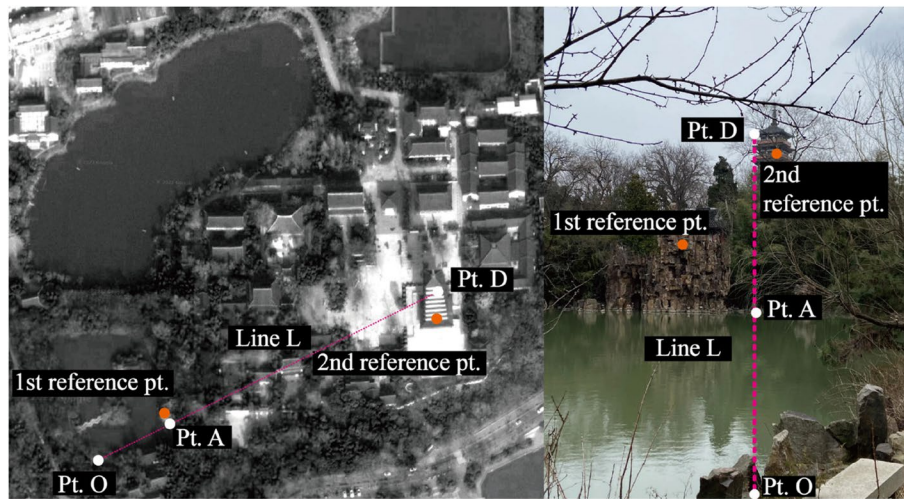


Fig. 5 Photograph-based objective extraction for studying the pattern of visitors' preferences. The photographs were obtained by the following method. First, a central point *A* was selected and extended to the target point *D*. Second, based on the projection of two spatial points and 1 spatial line, observation point *O* and sight *L* were determined. By geoinformatics calculation, the visitor's preferred point of view was determined (Source: the authors)

However, while it was not possible to obtain KDEs for the study area in 1962 and 1973, this had no negative impact on the current study because the 2022 KDE used in this study was employed to determine the temple's current spatial layout and visitor perceptions. The geographic coordinates extracted from the typical photographs were processed into valid geodata as point elements. Data were input to ArcGIS software for further processing (geodetic datum: WGS84), and the distribution density of visitors in space was calculated through the KDE tool in the ArcGIS toolbox to obtain the index of visitor perceptions for each attraction. KED can be calculated by Formula (1) as follows:

$$f(s) = \sum_{i=1}^n \frac{1}{h^2} k\left(\frac{d_{is}}{h}\right) \quad (1)$$

where $f(s)$ is the KDE function, h is width, d_{is} is the Euclidian distance from i to s , and k represents classical Gaussian kernel functions.

In addition, some parameters in the space syntax were also adopted in the current study. Brief introductions of the data-processing method are given as follows. An 'isovist' is defined as a visual record of a panorama view (360° field of view) visible from a given vantage point at average eye height (Benedikt 1979); it is considered a visual record of the field of view that reflects the space from the perspective of the visitor as they experience, interact with, and move through a space (Turner et al. 2001). The concept of 'spatial sequence' is based on the work of G. Cullen and commonly defined as the

'isovist' obtained from each vantage point along a chosen route in built environments (BEs) (Cullen 1971). Multiple spaces organised into sequences form a 'spatial sequence'. It is believed that 8 m is the spacing distance that reflects changes in visitors' visual perceptions as they move along tour routes (Payntar et al. 2021); therefore, a distance of 8 m was chosen as the spacing distance between two viewpoints to divide the spatial sequence along the tour route. Relationships between the Euclidean distance and the magnitude of spatio-temporal variation are significantly representative in the organisation of the spatial sequence (Nasar 1987), indicating that the magnitude of change in the radius is also proper for reflecting visitors' visual perception. Therefore, to represent the dynamic relationships in the spatial sequences in the research, the 'radius' obtained from the VGA model was used as a reference.

A visibility graph analysis (VGA) model within the space syntax system was proposed by Turner and Penn (2001); its algorithm is based on studies by Benedikt (1979), and it can be applied at both the eye level and knee level (Turner and Penn 1999). In the VGA model, the total depth (TD) parameter is defined by the number of spaces one must pass through from a chosen or given starting point in the system, whereas the mean depth (MD) parameter in the VGA model is often adopted to calculate the spatial integration along the spatial consequence (Hiller and Iida 2005). The MD value is determined by the number of knots connected to a knot (Hiller and Iida 2005) and can be calculated as shown in Formula (2):

$$MD_i = \frac{\sum_{j=1}^n d_{ij}}{n-1}, i \neq j \quad (2)$$

where n is the number of knots in the topological system, and d_{ij} is the shortest topological distance between any pair of points.

2.3 Tour routes along spatial sequences

A representative tour route that existed in the temple during each of the three examined periods and tour routes chosen according to their spatial sequences were drawn to conduct spatial syntax analysis. To further investigate spatial changes in visitors' perceptions of the main tour routes before and after the construction of the Qiling Pagoda and the eastern district, geoinformation on the tour route was obtained. To determine changes in visitors' visual perceptions, the tour routes were manually divided into small increments by a parametric Grasshopper program within Rhinoceros 7. Viewpoints are defined as specific points of sections located along the tour routes. The tour routes of the Daming Temple used in the 1960s and 1970s have not been changed. For presentation, the viewpoints have been numbered S1, S2, S3, etc. There was a total of 127 viewpoints in 1962, 134 viewpoints in 1973, and 191 viewpoints in 2022 (Fig. 6). The data were imported into ArcGIS software to conduct a perceptual analysis of the openness of the space, and the results are compared with those of the VGA analysis.

2.4 Types of spatial sequences

It was observed that diverse types of spatial sequences exist in the temple. We classified 14 spatial landscape narrative patterns in the order of <8 m, 8–25 m, 25–100 m, 110–390 m, and >390 m, considering the scale of the visual interface with different degrees of enclosure and the visible distance of common adults (Liu and Zhang 2010; Yang and Yang 2022). The level of accessibility and the level of visibility in the temple space were not theoretically homogeneous; thus, we summarised 3 types of spaces, i.e., enclosed spaces, enclaved spaces and open spaces, including 10 subtypes of spatial sequences (Table 1).

3 Results

3.1 Distribution of visitors' spatial preference

The visualisation of landscape elements was conducted within the ArcGIS software (Fig. 7), while the distribution map of visitors' spatial preference in the temple space was created by importing points of volunteer visitors' positions into ArcGIS software (Fig. 8). Calculations were performed using the standard KDE method. In Fig. 8, the warmer hues represent higher nucleus density values, while the cooler hues represent lower nucleus

density values. It can be observed that the open space between Mahavira Hall and Qiling Pagoda is the place with the highest degree of convergence. Explicit convergence is also found in the areas surrounding the popular tourist route, i.e., that containing Pai Lau, Temple of the Heavenly King (known as '*Caturmahārājakayikas*' in Sanskrit), Clear Sky Pavilion, Ping Yuan Hall, Mahavira Hall and the Qiling Pagoda. These sections along the route have a good range of visitor services and attractions for visitors to take photographs. However, non-Buddhist visitors are less likely to attend the Buddhist rituals and ceremonies available along a specific route, i.e., that containing the Preceptor, Reclining Buddha Hall, Miyan Yatra, the book depository and Vimala House (known as '*Vimalakīrti*' in Sanskrit), which describes the spatial religious functionalities of the easternmost part of the eastern district; furthermore, areas located along the specific route belong to different schools of Buddhism. Therefore, Buddhists will only enter certain specific areas.

Simultaneously, the 2022 spatial accessibility was quantified using the VGA model (Fig. 9). By comparing the spatial preference distribution map and the MD value in the VGA model of each site, we filtered out some sites that were not easily accessible but still visually attractive to visitors, e.g., although the fifth spring was less accessible than other sites, the existence of rocky gardens, waterscapes and pavilions in the area made this spot attractive for visitors to take more photographs. Visitors' favourite sites were located along the horizontal and vertical axes of the landscape, which effectively organised the space and influenced most visitors' visual preferences.

3.2 Radius along spatial sequences

In the VGA model, the value of the radius reflects the curvature of the visible 2-D plane and the width of the space, and the degree of visibility in the VGA model reflects the spatial openness at the viewpoint (Hiller and Iida 2005). The radius measurements at each point along the trials were processed and presented by a Python program using the Matplotlib and Scikit-learn packages. The variation in the radius along the main tour routes during the 3 study periods is quantitatively visualised in Fig. 10.

Variation in the minimum radius value at the level of accessibility in the 1960s cannot be clearly seen, as visitors' apparent movements were seemingly limited at the crossings. Once past the Qiling Pagoda, the width of the path became narrow, motivating visitors to walk through the adventure area. The minimum radius of visibility occurred in sections S53–S104, indicating that when visitors entered the western garden, the surroundings became boarder, and there was no intense sense of spatial enclosure (Appleton 1994). The maximum radius at the level of accessibility fluctuated, while the range of



Fig. 6 Viewpoints along tour routes in the temple heritage spaces in 3 different periods. To study the changes in visitors' visual perceptions, the tour routes were divided into small increments. Viewpoints are defined as specific points in sections located along the tour routes, which are numbered as S1, S2, S3, etc. (Source: the authors)

variation remained in the range of 6.53 –70.52 m. This indicates that the movement of visitors in the spaces were tortuous. The minimum radius at the level of visibility occurred in sections S53–S104, indicating that the surroundings were broader and that an intense sense of enclosure was absent when visitors entered the western garden (Appleton 1994).

There are slight changes in the radius found for 1973. The main difference between the conditions of the 1960s and those in the 1970s was located in section S35–S48, which corresponds to the section containing Jianzhen Memorial Hall and Ouyang Xiu Memorial Hall. The explicit difference in the maximum radius creates a transitional spatial experience between the

Table 1 Types of spatial sequences. Three types of spaces, i.e., enclosed spaces, enclaved spaces and open spaces, are summarised and identified, including ten subtypes of spatial sequences

Types of spaces	Spatial patterns	Characteristics	Properties
Enclosed	A: the level of accessibility, area < 50 m ² the level of visibility, area < 50 m ²	Spatially centripetal inwards and enclosed	Small area of both level of visibility and accessibility; the space is both closed and centripetal
	B: the level of accessibility, area < 50 m ² the level of visibility, area = 50–490 m ²	with diffusion, which induces visitors' movements	
	C: the level of accessibility, area = 50–490 m ² the level of visibility, area = 50–490 m ²	Inwards and stable	
Enclave (Semi-open)	D: the level of accessibility, area < 50 m ² the level of visibility, area = 490–9,500 m ²	Extroversion, induces movements	Fewer areas with relatively high levels of accessibility; more areas with relatively high levels of visibility The view is more open
	E: the level of accessibility, area < 50 m ² the level of visibility, area = 9,500–19,400 m ²	Outwards facing, wide-open views	
	F: the level of accessibility, area = 50–490 m ² the level of visibility, area = 490–9,500 m ²	Relative spatial stability; inwards spatial equilibrium	
	G: the level of accessibility, area = 50–490 m ² the level of visibility, area = 9,500–19,400 m ²	Relatively stable, with 'borrowed landscape'	
Open	H: the level of accessibility, area = 490–9,500 m ² the level of visibility, area = 490–9,500 m ²	Relatively high level of openness	The level of accessibility and the level of visibility are both high. Weak sense of spatial enclosure
	I: the level of accessibility, area = 490–9,500 m ² the level of visibility, area = 9,500–19,400 m ²	Open spaces	
	J: the level of accessibility, area = 9,500–19,400 m ² the level of visibility, area = 9,500–19,400 m ²	Blurred spatial boundaries; vast	

architecture and the garden, highlighting the difference in the level of accessibility and visibility.

However, the 2022 radius values changed dramatically due to the redesign and innovation of heritage revitalisation in the eastern district, resulting in changes in sections S18–S103 (Mahavira Hall, Qiling Pagoda, Reclining Buddha Hall, and Ouyang Xiu Memorial Hall). Compared to earlier periods, the minimum radius of visibility and accessibility fluctuated significantly, indicating a decrease in the sense of multiple enclosures of the building space (Cullen 1971). The maximum radius fluctuated in the range of 8.88–152.81 m, which is positioned exactly in the open space of the revitalised and newly built area. The maximum radius of the level of visibility varied in the range of 13.30–242.63 m, while the maximum diameter of the level of visibility varied between 13.30–242.63 m, with a higher value for area S18–S103 compared to that of area S111–S171 (the western garden). This indicates that the more recent architectural heritage spaces are more open than the temple gardens. There is also a

reverse correlation between the level of visibility and accessibility in the western garden in all 3 periods.

3.3 Variations along the spatial sequences

During the three examined periods of the construction of the temple, the spatial types of those spaces in which each viewpoint is located were classified according to the level of accessibility and the level of visibility at each viewpoint (Fig. 11).

There were three peaks along the main tour route in 1962; these peaks were located at Mahavira Hall, Pingshan Hall and the western garden (Fig. 12). The first peak was located in Mahavira Hall, i.e., the central position of the global space, and represents its functionality regarding religious edification. As visitors moved from the Qiling Pagoda to Mahavira Hall, the space gradually became closer, promoting mental relaxation for the visitor. As visitors left the Hall of Heavenly Kings and entered Mahavira Hall, the space was gradually becoming open again, creating an atmosphere of 'Samadhi' sanctity in the Buddhist religious sites. The second climax

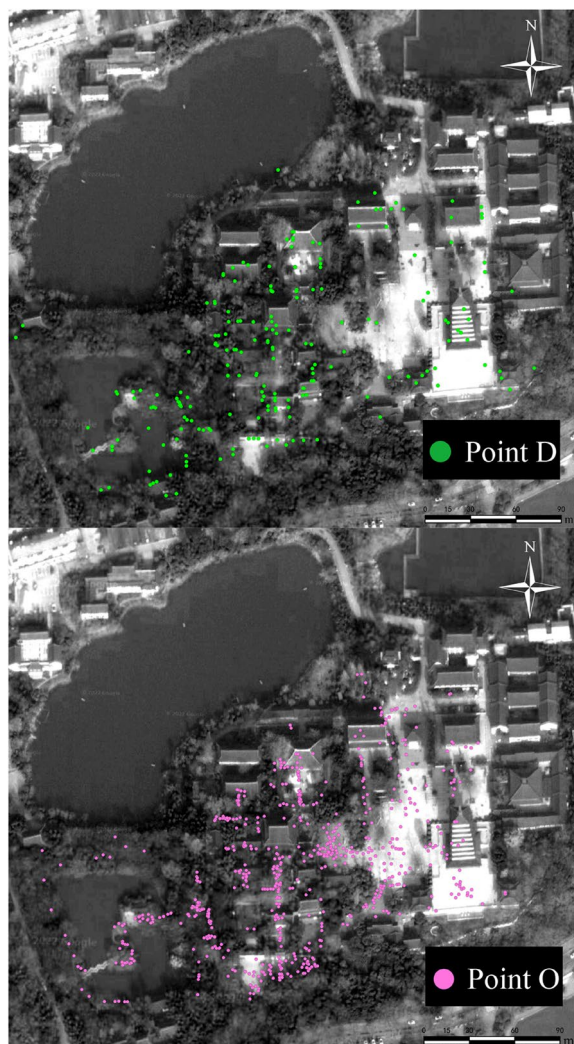


Fig. 7 Visualisation of landscape elements within ArcGIS. The left panel presents the standing location points of each visitor when they took their photographs, the middle panel presents the visitors' preferred viewpoints, and the right panel presents the line between the standing location points and the visitors' preferred viewpoints (Source: the authors)

occurred when the visitors walked through the centre of the pool in the western garden. As visitors moved from the fifth pavilion to the centre of the pond, the stacked rockery gradually ceased, and a meandering path gradually emerged, from which distorted views motivated visitors to appreciate the waterscape, which represents the world of pure land (*'Sukhavati'* in Sanskrit); the pool was also used by Sukhavati Buddhists to release captured fish. The third climax was observed at the sites surrounding Pingshan Hall, which is the residence built by the literati Ouyang Xiu and a well-known tourism attraction. At this time, the view from Pingshan Hall presented a centrality

of visibility created by the landscape design technique called the 'borrowed landscape' (Gu et al., 2017).

Some variations were discovered for the examined sites in 2022. When visitors arrived at the site, the suddenly occurring open spaces and distant views enhanced their visual experience. Section S18–S103 (Mahavira Hall, Lingqi Pagoda, Reclining Buddha Hall, and Ouyang Xiu Memorial Hall), where the visitor's view shifts between enclaved and open spaces, was the focus of noticeable fluctuations in the spatial sequence of the temple heritage spaces in 2022. Sections P103 to P191 alternate between closed and enclaved conditions, providing one with the delightful experience of 'looking out of enclosures' (Cullen 1971).

To analyse how the variation in landscape sequence along the tour routes may affect visitors' visual preferences, we compared the MD values along the main tour routes with the changes in visitors' visual preferences according to the level of openness and the geoinformatics analysis of the photographs. The MD values were extracted from DepthMap software. Simultaneously, valid geodata were extracted from each vantage point. Quantitative comparisons of relationships between visitors' spatial preference distributions and spatial openness were conducted using the Python program. To compare the visitors' spatial preferences and the MD values, the results were visualised by the Python program with the Matplotlib, Scikit-learn and Panda packages. The values on the y-axis represent the normal KDE, knee-level accessibility and eye-level visibility, while the values on the x-axis represent the ordered viewpoints along the tour route (Fig. 13).

4 Discussion

4.1 Analysis of visitors' spatial perceptions in specific spaces

The geoinformatics analysis of the photographs showed that the spatial perception along the tour route in the western garden is different from that in the remaining spaces. The section containing the fifth spring and Sifang Pavilion has a low level of both accessibility and visibility, with the level of accessibility being lower. The section containing Qiling Pagoda and Jianzhen Memorial Hall has higher MD values for accessibility and visibility. Visitors' visual preferences are not noticeable, even though the level of accessibility is higher in this section. Although the eastern district has a strong attraction for visitors, visitors lose their sense of curiosity during their stay in the eastern district after visiting Suling Pagoda. In other words, most visitors often prefer to stay in preserved heritage spaces instead of staying in newly built areas. This phenomenon can be explained as follows:

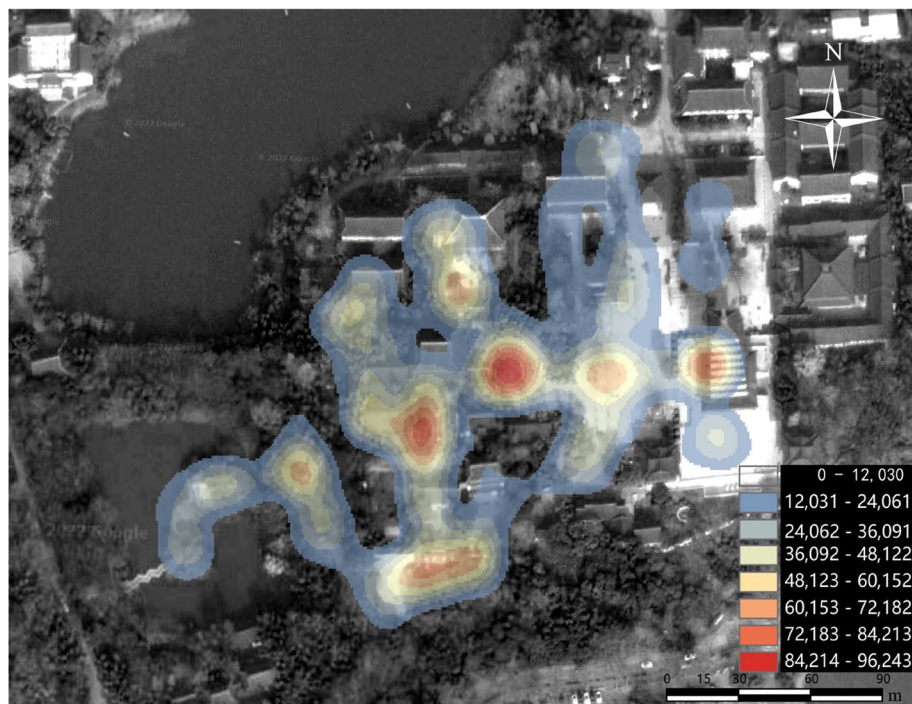


Fig. 8 The distribution map of visitors' spatial preferences. The figure was created by importing points of volunteer visitors' positions into ArcGIS. The warmer hues represent higher nucleus density values, and the cooler hues represent lower nucleus density values (Source: the authors)

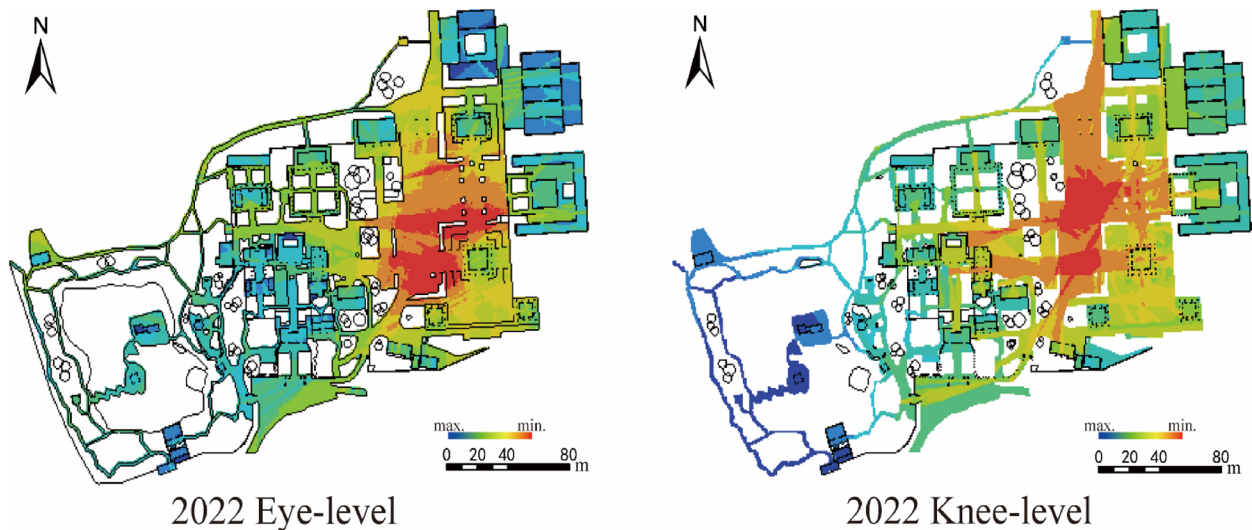


Fig. 9 MD values in the VGA model of the temple heritage spaces in 2022. The MD values of the temple heritage space in 2022 were calculated both at the eye level and the knee level. We found some sites that are not easily accessible but still visually attractive to visitors; we also found 'spatial organising' effects of horizontal and vertical axes of the landscape on visitors' visions (Source: the authors)

(1) Given its landscape elements that evidence a strongly conventional pattern, the spatial configuration of the Buddhist functional area in the Daming Temple represents a symmetrical and hierarchical pattern in its spatial configuration; thus, the main

tour route in the Buddhist functional area of the temple has a narrative 'guiding' effect on visitors (Kim et al., 2019). However, the spatial arrangement of the western garden and the eastern district is somewhat asymmetrical, with variations

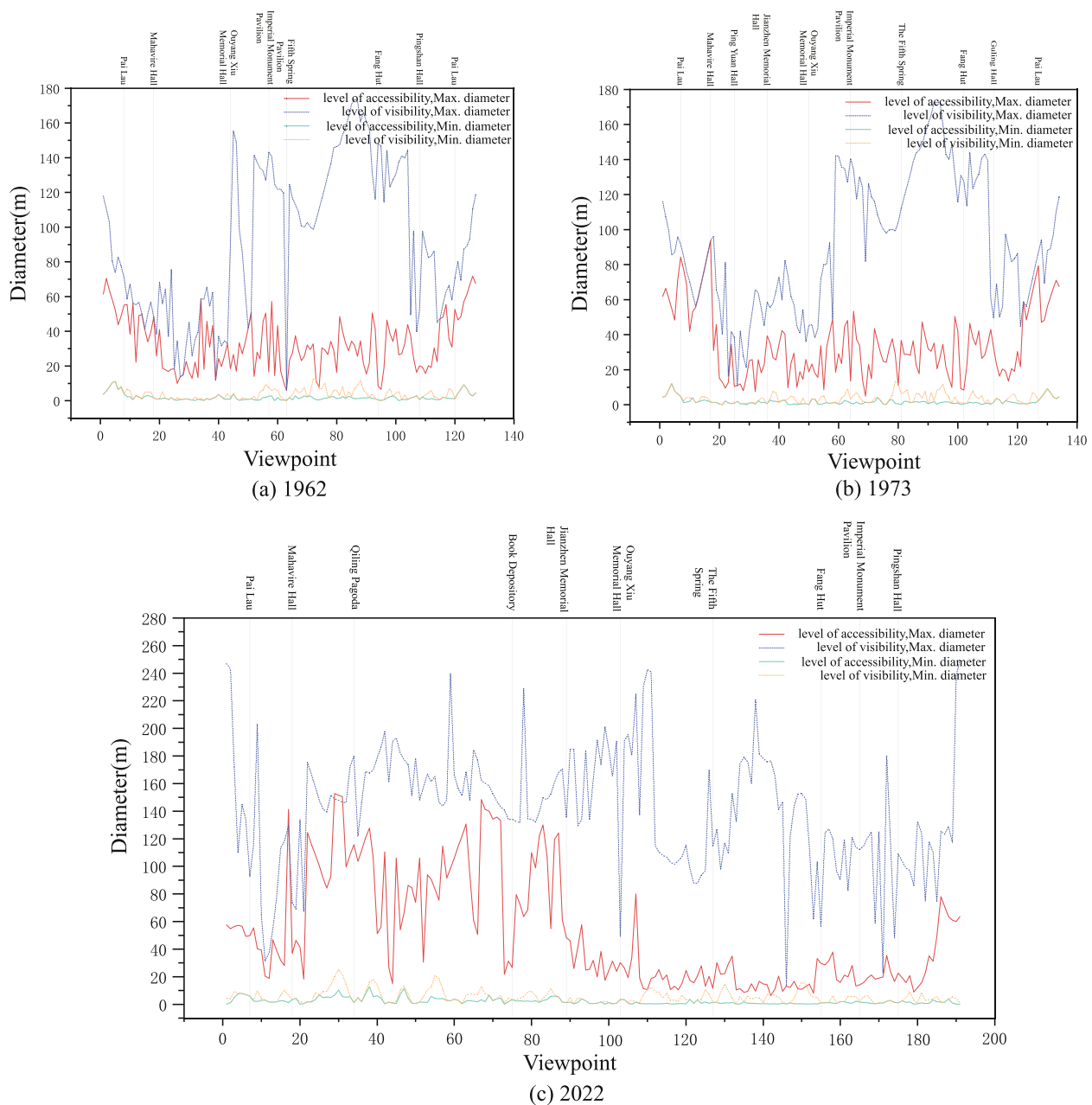


Fig. 10 Variation in the radius along the main tour route in the three study periods. The radius measurements at each point along the trail are presented. The spatio-temporal variation in the values of the radius along the main tour routes in the three study periods is quantitatively revealed. The changes in the radius were related to the redesign and revitalisation of heritage spaces in 1973 and 2022 (Source: the authors)

in openness. This spatial pattern was found less structured, which was in alignment with the typical narrative spaces for religious practices of literati Buddhists. As a result, most visitors have a comparatively low level of intention to stay in these areas, which is similar to some Buddhist temple heritages constructed by various Buddhist schools during diverse periods (Moonkham and Duff 2021). Some

narrative spaces in the temples are seen as much more than merely sacred places, similar to findings in some cases of developing Buddhist temples (Moonkham and Chladek 2023).

- (2) Views from adjacent spaces with distinct differences are compared, emphasising the narrative characteristics of in-between spaces. This emphasis is reflected in the global structure of the spatial

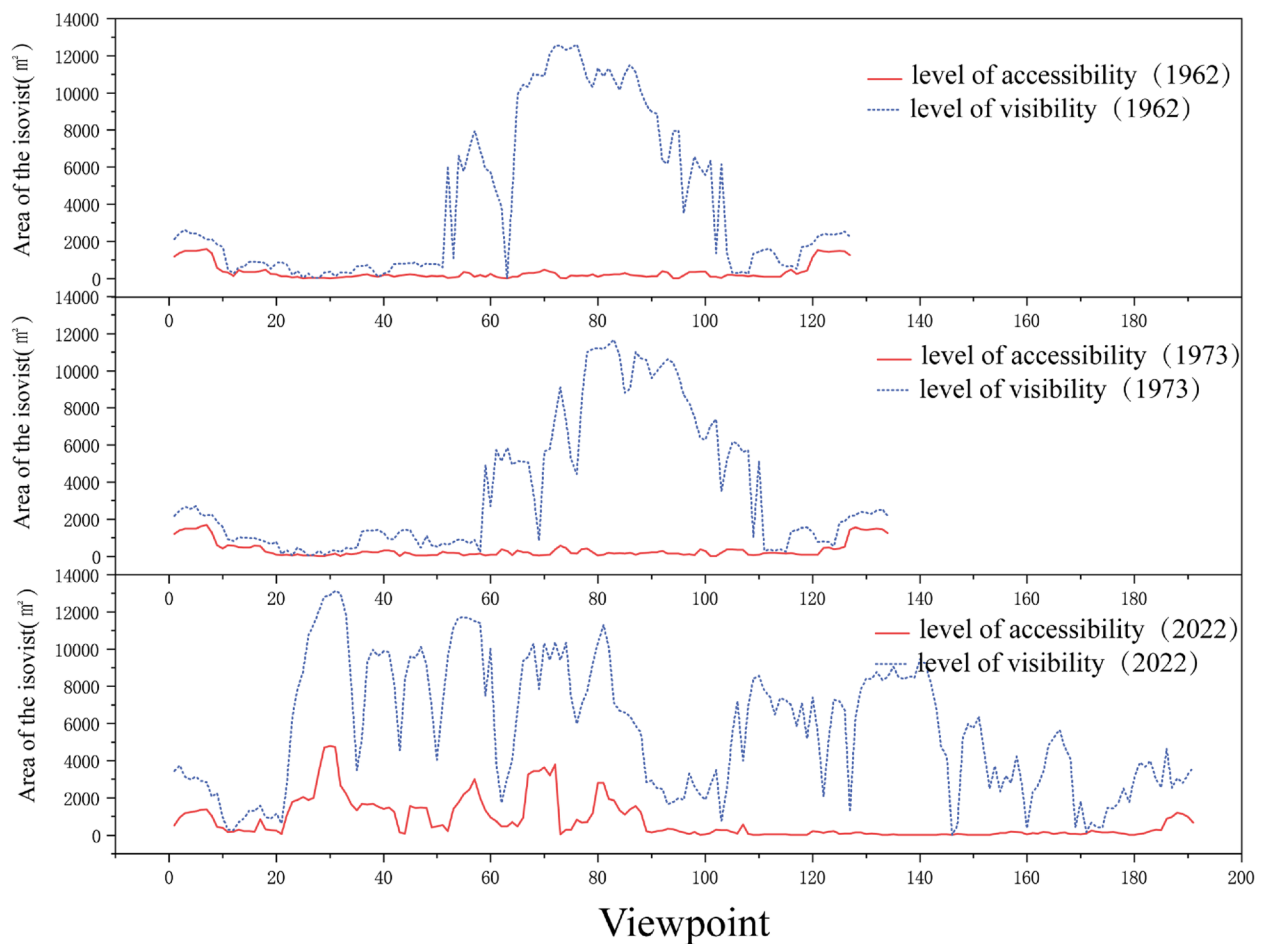


Fig. 11 Analysis of the level of visibility and accessibility along the main tour routes. This indicates that the types of spaces in which each viewpoint is located are related to the level of accessibility and visibility (Source: the authors)

sequences, which is less prominent in central areas but more significant in the periphery, corresponding with the phenomenon observed by Gu et al (2017).

- (3) Landscape features in the western garden frequently incorporate adjacent views to enrich the visitor's visual experience, which improves the visual immediacy and enhances narrative imaginaries (Appleton 1994).

4.2 Analysis of the spatial sequence among dynamic temporal changes

In all periods, the sections with lower MD values and lower levels of visitor presence are the section containing the Qiling Pagoda and Jianzhen Memorial Hall and the section containing the fifth spring and Sifang Pavilion. The construction of Jianzhen Memorial Hall in the 1960s did not obviously change the visual perception of visitors during the main itinerary. This outcome indicates that

these sections maintain their centralities along the main spatial sequence.

Some changes have taken place in other areas over time. During the 1960s and 1970s, the distribution of spatial enclosure varied in the spatial sequence due to the redesign of a narrow-width guiding space at the entrance of the temple's former centralistic spatial area. This construction made some tourism attractions more noticeable. In 2022, it was observed that visitors' perception of the eastern district varied following the completion of the heritage revitalisation project. This phenomenon may have occurred due to the availability of new attractions along the visitor's route that are quite distant from the Buddhist functional area, such as the book depository, Vimala House, and Reclining Buddha Hall. In the northeastern part of the eastern district, Miyan Yatra (a Vajrayana Buddhist building) and Vimala House (a Zen Buddhist building) might prompt some Buddhist visitors to tailor their itineraries to take specific pilgrimage

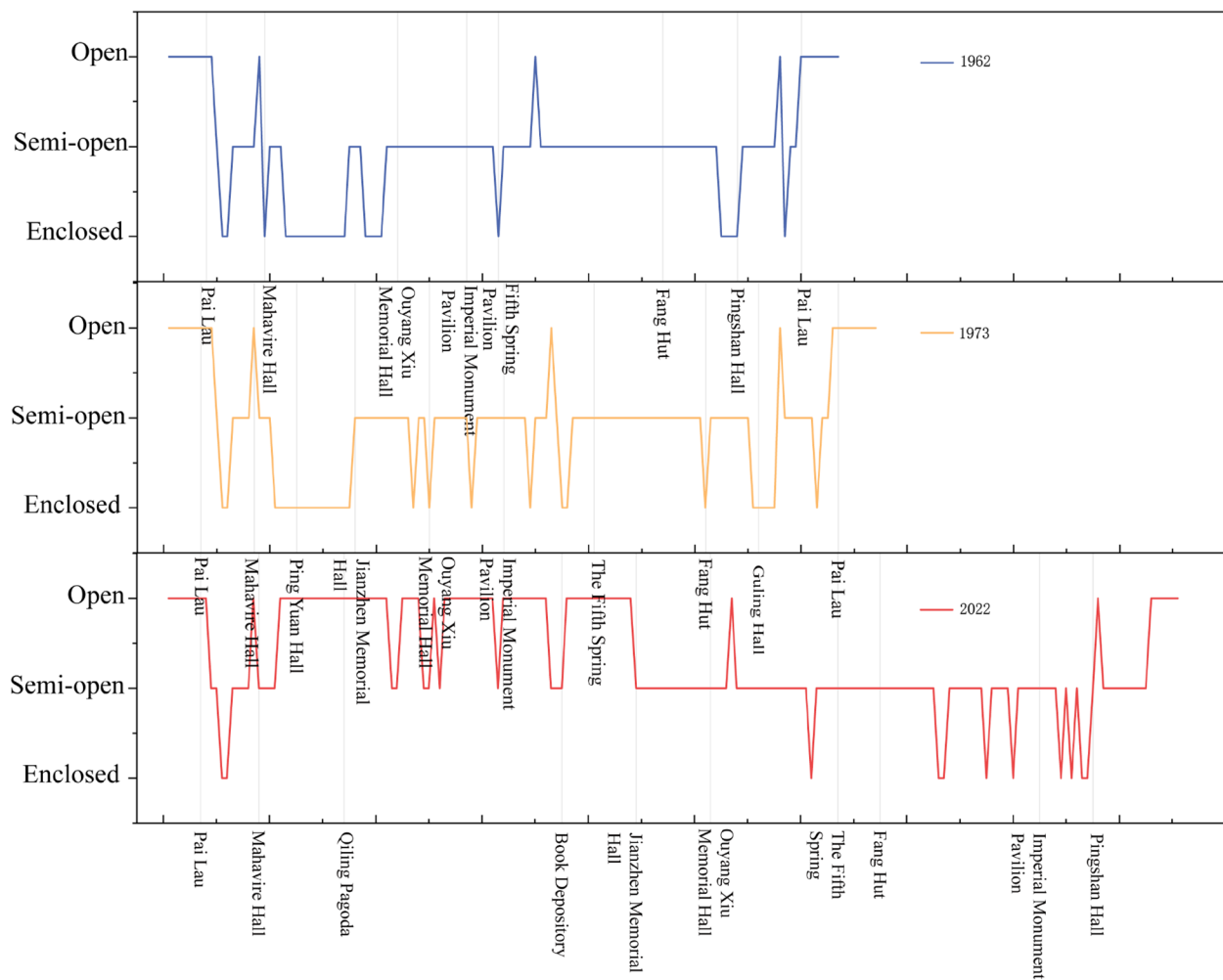


Fig. 12 Variation in types of space along spatial sequences in the temple space. The levels of visibility and accessibility along the tor route in the three study periods are visualised. It was discovered that there were three peaks along the main tour route in 1962 and that the sudden-occurring open spaces and distant views enhanced their visual experience in 2022 (Source: the authors)

routes. However, these buildings fail to attract the majority of tourists.

Thus, it is proposed that the spatial narrative process along the spatial sequence of the main tour route has an impact on visitors' spatial perception, which is primarily influenced by the religious functionality of the Buddhist buildings and temple gardens; this impact is highlighted when visitors move through a series of heterogeneous spaces (Kaplan and Kaplan 1989). These findings are consistent with the outcomes of another survey of a similar heritage site (Zhou et al., 2023).

4.3 Analysis of narrative spaces along the spatial sequence

At Buddhist heritage sites, the distribution of space for holding events and rituals is often believed to follow unique spatial organisation features, which may also affect visitors' preferences, especially Buddhist visitors

(Sawanobori 1985; Moonkham and Duff 2021). It is thus suggested that the spatial sequences within the Daming Temple follow a narrative structure that evokes visitors' emotions through a multi-stage narrative process consisting of a beginning, development, and a climax. Since the construction of the eastern district, variations in temporal visual perception have also been found. As the 'culmination' of the spatial sequence in the 'narrative' process (Zaninović et al. 2018), Lingqi Pagoda presents explicit and unique impacts. Thus, we propose that Mahavira Hall is the 'beginning' of the spatial sequence, while the path between Mahavira Hall and the Lingqi Pagoda is the 'developing' stage of the 'narrative' process.

By enhancing the contrasting experiences between these stages, visitors can attain a clearer understanding of the 'narrative semantics' of the site. This highlights the fact that visitors' interpretation of temple heritage can

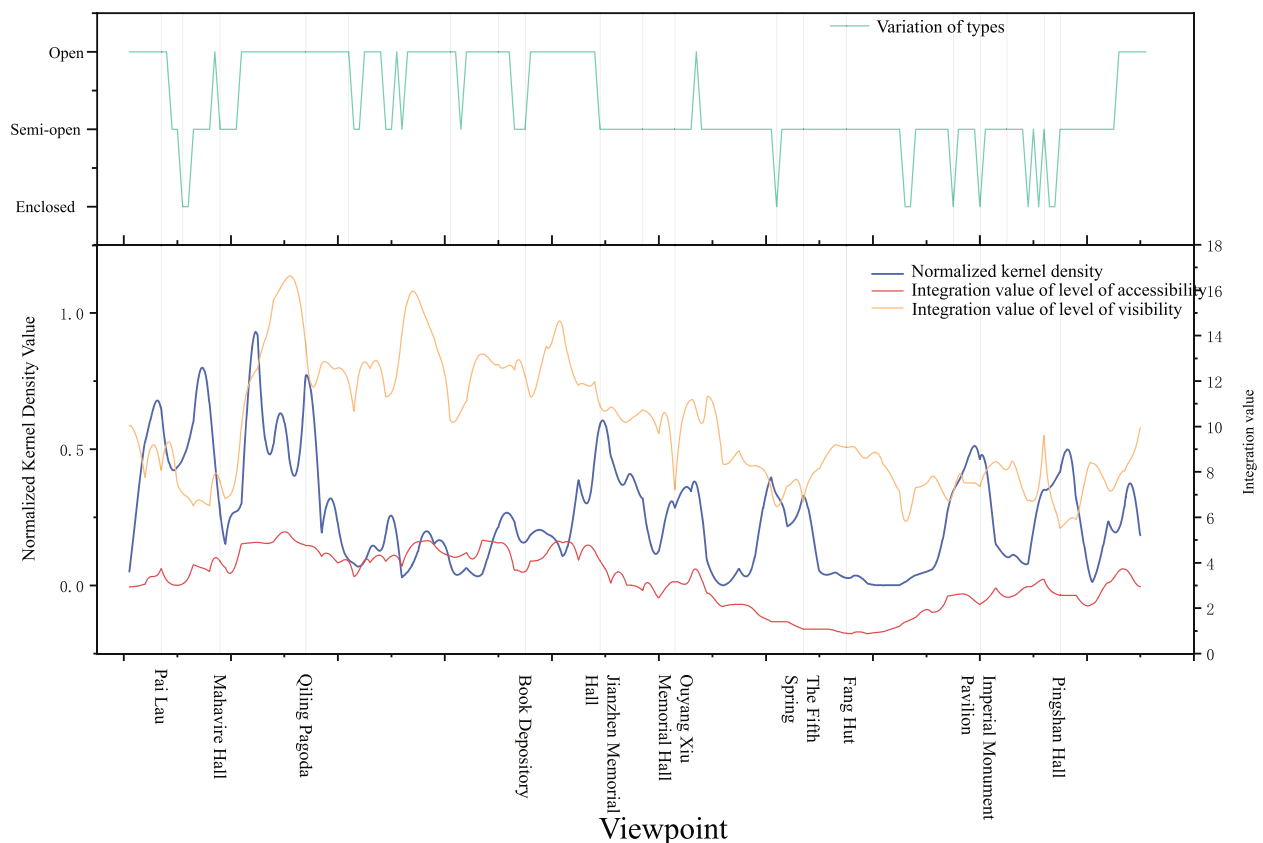


Fig. 13 Comparison between visitors' spatial preference and the MD values. The comparison was made according to the degree of the openness and the geoinformatics analysis of the photographs to analyse how the variation in landscape sequence along the tour routes may affect visitors' visual preferences. The values on the y-axis represent the normal kernel density, knee-level accessibility and eye-level visibility, whereas the values on the x-axis represents the ordered viewpoints along the tour route (Source: the authors)

reveal more abstract aspects of the landscape's narrative process. These narrative qualities create a 'living sacred landscape' with imaginative experiences linked to spatial hierarchies based on Buddhist cosmology (Moonkham and Chladek 2023). This visual experience also corresponds to the imagery of 'Mountain Sumeru in a mustard seed' and 'fifty-three pilgrimages of Sudhana kumāra' mentioned in *Mahvaipulya Buddhāvataṃsaka Sūtra* and *Avatamsaka Sūtra*, which is created by a rich variety of openings and closings in a limited space. This finding is consistent with the existing research on visual perception (Mate 2022) and can explain visitors' episodic experience in continuous narrative spaces.

Additionally, it is noticeable that most spaces in the eastern district surrounding the Lingqi Pagoda are relatively open, making them spatially and temporally monotonous and less likely to trigger variations in perceptual images and psychological responses (Shin 2022). Visual interactions between visitors and space are often more apparent in 'borrowed' landscapes, which are successful in developing narrative spaces to incorporate

background scenery and heritage spaces (Luyat 2013; Gu et al. 2017). In addition, as visitors move through the eastern district, their visual perceptions are blocked and screened frequently by some obstacles in the viewshed, e.g., some micro-topologies and rockeries, which may lead to shorter durations of stays. The enclaved layouts of certain semiprivate spaces for religious ceremonies, i.e., the Vimala House for Zen Buddhists, the Preceptor for Vinaya Buddhists and the Miyan Yatra for Vajrayana Buddhists, have a high level of internal concealment and are designed for stimulating mysterious experiences and religious senses, which affect the visitors' visual perception of their spatial narrative characteristics.

Additionally, certain landscape design methods utilised in traditional Chinese gardens, such as the concept of 'borrowed landscape' (Yang and Yang 2022), adhere to the typical characteristics of a narrative process. Such landscape design techniques have been shown to be effective at evoking visitors' visual preferences, consistent with Wei et al (2022). These landscape techniques may be beneficial in the revitalisation design of newly

constructed areas during the further development of the Daming Temple.

In general, it is understood that tourists' visual preferences and behaviours are influenced by various factors, as evidenced by existing research (Li 2015; Shin 2022). It has been confirmed that the mechanisms of the spatial narrative are complex and rely on perceptual and phenomenological factors. This concept is closely related to the spatial configurations of temple heritage spaces.

4.4 Suggestions for further studies

Some improvements could be applied in further studies; these improvements are listed as follows:

- (1) The tour routes selected in this study are of a single type; thus, other types of heritage spaces with more dynamic and complex tour routes should be studied.
- (2) Some of the criteria used in this study to delineate spatial sequences could, where possible, be replaced by more appropriate alternatives in further research.
- (3) Photograph-based geoinformatics analysis techniques are more appropriate for researchers focusing on landscape design, as shown in a few similar studies (Yang and Yang 2022). However, the generalisability of this method still needs to be demonstrated by more empirical cases. We suggest that future research further explore nonspatial-oriented factors.
- (4) The *in-situ* survey also found that the temple heritage space lacks landscape facilities for tourists to rest, while some of the tourist attractions need to be optimised for redesign, e.g., the entrance of the pavilions. In addition, the Qingfeng Pavilion was screened by arbours and had insufficient visual exposure. Therefore, if possible, before and after comparisons could be further conducted.

5 Conclusion

The current study analysed and explained the narrative spaces located along the spatial sequence of the Daming Temple. The preliminary findings of the quantitative geodata analysis techniques indicated dynamic spatial sequences across different periods. It was discovered that visitors generally preferred the Qiling Pagoda in the eastern district. The visual preferences of visitors in other areas paled in comparison to those in newly built areas. Meanwhile, impartial visitors demonstrated a preference for the western garden, despite its lower level of accessibility in its overall space. Additionally, the spatial narrative characteristics showcased a fluctuating progression, as evidenced by the analysis of spatial sequences along

the main tour routes. The construction of the Jianzhen Memorial Hall in the 1960s did not lead to any discernible impact on the narrative process along the existed spatial sequences. However, the redevelopment of the eastern district altered both spatial sequences and visitors' visual perception. Nevertheless, some religious functional sites in the eastern district were shown to have little appeal for most visitors. The spatial sequence was shown to have an impact on visitors' visual preferences and their perceptions of the narrative process during their itineraries.

These findings may suggest spatial redesign strategies that can be used to enhance the design and management of spatial sequences along tour routes in heritage areas while simultaneously considering the impact of the spatial narrative. These findings can also serve as points of reference for landscape architects, heritage geographers and heritage managers to improve spatial redesign, tourism service design and management for similar built heritage sites, especially ancient temple heritage sites located in East Asia.

Abbreviations

BE	Built environment
GIS	Geographic information system
KDE	Kernel density estimation
MD	Mean depth
POE	Post-occupancy evaluation
VGA	Visibility graph analysis
UHL	Urban historical landscape

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s43238-023-00105-0>.

Additional file 1.

Acknowledgements

The authors would like to express their sincere thanks to Cultural Publicity Department of the Daming Temple, Jiangsu Province, P. R. China.

Authors' contributions

Conceptualization, W. W. and K. Z.; methodology, X. D., K. Z. and T. L.; software, K. Z. and T. L.; resources, W. W.; writing—original draft preparation, K. Z. and T. L.; writing—review and editing, T. L. and X. D.; visualization, T. L. and K. Z. All authors have read and agreed to the published version of the manuscript.

Funding

This research was supported by the National Natural Science Foundation of China (project #52278083) and the Ministry of Education Humanities and Social Sciences Research Planning Fund (project #18YJAZH103).

Availability of data and materials

The datasets used and analysed in this article is included within the article and its additional file.

Declarations

Consent for publication

Not applicable.

Competing interests

The author declare that they have no competing interests.

Received: 14 May 2023 Accepted: 4 October 2023

Published online: 15 November 2023

References

- Appleton, J. 1994. *How I made the world: Shaping a view of landscape*, 255. Hull: University of Hull Press.
- Arbara, S. 2022. A configurational approach to cultural heritage attractors: Diachronic space syntax analysis in the historic urban area of Rome. In *Proceedings 13th International Space Syntax Symposium, History & Urban Morphology: Historic centre and village conservations*, edited by Akkelies van Nes and Remco de Koning. <https://www.hvl.no/en/research/conference/13sssf/>.
- Benedikt, M. L. 1979. To take hold of space: Isovists and isovist fields. *Environment and Planning b: Planning and Design* 6: 47–65.
- Breadsell, J. K., J. J. Byrne, and G. M. Morrison. 2019. Pre-and post-occupancy evaluation of resident motivations for and experiences of establishing a home in a low-carbon development. *Sustainability* 11: 3970.
- Chen, G., J. Bowring, and S. Davis. 2023. Exploring the Terminology, Definitions, and Forms of Post-Occupancy Evaluation POE in Landscape Architecture. *Land* 12: 882.
- Cullen, G. 1971. *The concise townscape*. Oxford, UK: Oxford Architectural Press.
- Edwards, B., T. Frasci, and J. Jeyacheya. 2019. Evaluating the effectiveness of land-use zoning for the protection of built heritage in the Bagan archaeological zone, Myanmar—A satellite remote-sensing approach. *Land Use Policy* 88: 104174.
- Geng, S., H. Chau, E. Jamei, and Z. Vrcelj. 2022. Understanding the street layout of Melbourne's Chinatown as an urban heritage precinct in a grid system using space syntax methods and field observation. *Sustainability* 14: 1–26.
- Gu, N., R. Yu, and M. J. Ostwald. 2017. Unpacking the cultural DNA of traditional Chinese private gardens through mathematical measurement and parametric design. In *2013. The gardens of Suzhou: Penn studies in landscape architecture*, edited by R. Henderson. Philadelphia: University of Pennsylvania Press.
- Guo, Q. 2015. *Development trend of the architectures with Chinese characteristics under the impact of western culture*. In *Proceedings of the International Conference on Education, Management and Computing Technology (ICEMCT-15)*, 166–170. Atlantis Press. <https://doi.org/10.2991/icemct-15.2015.35>.
- Hegazi, Y., D. Taha, N. Abdel-Fatah, and M. El-Alfi. 2022. Socio-spatial vulnerability assessment of heritage buildings through using space syntax. *Heliyon* 8: e09133.
- Hillier, B., and S. Iida. 2005. *Network effects and psychological effects: a theory of urban movement*, 13–17. Delft: 5th International Symposium.
- Kaplan, R., and S. Kaplan. 1989. *The experience of nature: A psychological perspective*. UK: Cambridge University Press.
- Karmilah, M., and N. Magfiroh. 2018. Using space syntax to determine the form and pattern of heritage site (Case study: Sangiran Heritage Site). *Jurnal Planologi* 15: 81.
- Kim, Y., C. K. Kim, D. K. Lee, H. W. Lee, and R. I. T. Andrada. 2019. Quantifying nature-based tourism in protected areas in developing countries by using social big data. *Tourism Management* 72: 249–256.
- Li, Z. 2015. Spatial structure and visitor behavior pattern of Chinese classical gardens: A case study of Yi Garden, Suzhou. In *Space Syntax in China*, edited by Jin Duan and Hillier Bill, 137–155. Nanjing: Southeast University Press.
- Li, T., Y. Huang, C. Gu, and F. Qiu. 2022. Application of geodesign techniques for ecological engineered landscaping of urban river wetlands: A case study of Yuhangtang River. *Sustainability* 14: 15612.
- Lin, H., Xing, K. and Chen, X. 2022. Research on Narrative Expression Design of Industrial Heritage Landscape Under the Implicit Process. *Journal of Progress in Civil Engineering* 4. [https://doi.org/10.53469/jpce.2022.04\(01\).06](https://doi.org/10.53469/jpce.2022.04(01).06).
- Liu, B., and T. Zhang. 2010. Landscape space sequence organization based on visual sense. *Chinese Landscape Architecture* 11: 31–35.
- Liu, G., and Q. Lu. 2019. The progress of traditional Buddhist temple landscape studies in China from the perspective of academic transformation. *Chineses Landscape Architecture*. 35 (4): 96–100.
- Luyat, A. 2013. Borrowed Scenery. *American Book. Review* 34: 22–22.
- Mate, G. 2022. Scale, meaning, experience: exploring landscapes. In book: *The Archaeology of Mount Shamrock*. 2022. *Mining the Landscape*. Cham: Springer Nature, 167–192.
- Mei, Y., Li, T., Jin, B. and Chen, W. 2020. Research on innovative design of microclimate environment in campus outdoor space. In book: *Processing of 2nd Landscape Architecture v.s. Microclimate International Conference*. China: China Architecture & Building Press.
- Moon, J. 2022. Storytelling and Cultural Tourism of Architectural Change in Mythology: Focusing on Bongjeongsa Temple in Andong. *Korean Association of Regional Sociology* 23: 123–147.
- Moonkham, P., and A. I. Duff. 2021. The social logic of the temple space: A preliminary spatial analysis of historical Buddhist temples in Chiang Saen, Northern Thailand. *International Journal of Historical Archaeology* 264: 849–884.
- Moonkham, P., and M. Chladek. 2023. Living sacred landscape: space, cosmology, and community in the Buddhist temples in Northern Thailand. In *The Oxford Handbook of Lived Buddhism*. London: Oxford University Press.
- Nasar, J. L. 1987. The effect of sign complexity and coherence on the perceived quality of retail scenes. In *Environmental Aesthetics Theory, Research, and Application*. Cambridge, Cambridge University Press.
- Palaologou, F. and S. Griffiths. 2019. The Uses of Space Syntax Historical Research for Policy Development in Heritage Urbanism. In *Cultural Urban Heritage: Development, Learning and Landscape Strategies*, Chapter: 2. Springer, Cham. https://doi.org/10.1007/978-3-030-10612-6_2.
- Payntar, N. D., W. L. Hsiao, R. A. Covey, and K. Grauman. 2021. Learning patterns of tourist movement and photography from geotagged photos at archaeological heritage sites in Cuzco, Peru. *Tourism Management* 82: 104165.
- Saraoui, S., A. Attar, R. Saraoui, and S. Alili. 2022. Considering luminous ambience and spatial configuration within the Ottoman old heritage buildings Algerian palaces focusing on their modern-day utility. *Journal of Cultural Heritage Management and Sustainable Development*, ahead-of-print. <https://doi.org/10.1108/JCHMSD-10-2021-0178>.
- Sawanobori, Y. 1985. On the relation between the space of secret-ceremony of tantric Buddhism and the space of temples. part 2: The Study on the space of Tantric Buddhism. *Journal of Architecture, Planning and Environmental Engineering (transactions of AIJ)* 351: 75–82.
- Shin, H. 2022. A study on the direction for Yangju Hoeamsa Temple site inscription as a world heritage site. *The Paek-San Society* 124: 343–367.
- Susnow, M. 2021. The space syntax of Canaanite cultic spaces: A unique category of spatial configuration within the Bronze Age southern Levant. *Bulletin of the American Schools of Oriental Research* 3851: 131–152.
- Susnow, M., and N. Goshen. 2021. House of a king, house of a God? Situating and distinguishing palaces and temples within the architectonic landscape of the Middle and Late Bronze Age southern Levant. *Levant* 531: 69–91.
- Susumu, K. 1974. Shitaku: The life and literature of a Bonze who came over to Japan. *Japanese Literature* 23 (1): 62–78.
- Turner, A., and Penn, A. 1999. Making isovists syntactic: isovist integration analysis. In: *Proceedings of the 2nd International Space Syntax Symposium*, Published by: Space Syntax Laboratory, UCL, UK. 103–121.
- Turner, A., M. Doxa, and A. Penn. 2001. From isovists to visibility graphs: A methodology for the analysis of architectural space. *Environment and Planning b: Planning and Design* 281: 103–121.
- Vasconcelos, C., T. Cruz, and T. Ribeiro. 2022. A natural park visitors' knowledge, attitudes and behaviours about sustainable development. In *Enhancing Environmental Education Through Nature-Based Solutions*, edited by Clara Vasconcelos and Cristina S. C. Calheiros, 221–230. Cham: Springer International Publishing.
- Wei, H., M. Zhou, S. Kang, and J. Zhang. 2022. Sense of place of heritage conservation districts under the tourist gaze—case of the Shichahai heritage conservation district. *Sustainability* 1416: 10384.
- Wang, Z. 2016. The current situation, problems and countermeasures of the new media promotion of Yangzhou cultural tourism brand—taking Daming Temple as an example. *Journalism and Communications* 04: 11–18.

- Xu, K., X. Chai, R. Jiang, and Y. Chen. 2023. Quantitative comparison of space syntax in regional characteristics of rural architecture: A study of traditional rural houses in Jinhua and Quzhou, China. *Buildings* 13: 1507.
- Yan, A., and H. Li. 2023. Dependence and subordination: Research on the development and changes of Chenghuang Temple and garden in Shanghai Qingpu District after the Ming Dynasty. *Humanities and Arts* 2: 54–60.
- Yan, J., J. Yue, J. Zhang, and P. Qin. 2023. Research on spatio-temporal characteristics of tourists' landscape perception and emotional experience by using photo data mining. *International Journal of Environmental Research and Public Health* 20: 3843.
- Yang, S., and Y. Yang. 2022. Cultural impacts on traditional Chinese garden design: A configurational comparison between traditional Chinese imperial and private gardens using space syntax. In *Proceedings of The 13th International Space Syntax Symposium*, 414. Bergen, Norway.
- Yu, R., N. Gu, and M. Ostwald. 2016. The mathematics of spatial transparency and mystery: Using syntactical data to visualise and analyse the properties of the Yuyuan Garden. *Visualization in Engineering* 4 (1): 4. <https://doi.org/10.1186/s40327-016-0033-y>.
- Zaleckis, K., H. A. Doğan, and N. L. Arce. 2022. Evaluation of the interventions to built heritage: analysis of selected façades of Kaunas by space syntax and sociological methods. *Sustainability* 14 (8): 4784. <https://doi.org/10.3390/su14084784>.
- Zaninović, T., F. Palaiologou, S. Griffiths, and B. Šćitaroci. 2018. Urban Landscape and Spatial Heritage: The Case of Gateway-Pathways in Zagreb, Croatia. *The Historic Environment: Policy & Practice* 9: 1–32.
- Zhao, Y., J. Liu, and Y. Chen. 2022. A creative analysis of factors affecting the landscape construction of urban temple garden plants based on tourists' perceptions. *Sustainability* 14 (2): 991. <https://doi.org/10.3390/su14020991>.
- Zhou, K., W. Wu, X. Dai, and T. Li. 2023. Quantitative estimation of the internal spatio-temporal characteristics of ancient temple heritage space with space syntax models: A case study of Daming Temple. *Buildings* 13 (5): 1345.
- Zolfagarkhani, M., and M. Ostwald. 2021. The spatial structure of Yazd courtyard houses: A space syntax analysis of the topological characteristics of the courtyard. *Buildings* 11: 262.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Submit your manuscript to a SpringerOpen[®] journal and benefit from:

- Convenient online submission
- Rigorous peer review
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

Submit your next manuscript at ► [springeropen.com](https://www.springeropen.com)