# EXTRACTING SPATIAL INFORMATION OF HERITAGE GARDENS FROM BOUNDARY PAINTINGS BASED ON 3D MAPPING TECHNOLOGIES

*USO DE TECNOLOGIAS DE MAPEO 3D PARA LA EXTRACCION DE INFORMACION ESPACIAL DE JARDINES HISTORICOS CHINOS A PARTIR DE PINTURAS DE ESTILO "LINEA REGLADA" (JIEHUA)*

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**Abstract:**

Boundary paintings, or *jie hua*, is a traditional Chinese painting style originally created for architectural design. Today, boundary painting is valuable for historic conservation since it provides accurate depictions of heritage gardens. However, this valuable evidence has not been fully decoded and used in conservation practices, because there is no effective method to translate these artworks into spatial information that can be directly applied. Therefore, the aim of this research is to demonstrate how to use 3D mapping technologies to decode boundary paintings and translate them into spatial indicators and parameters for spatial conservation of heritage gardens. This approach will be explored through building 3D virtual models of heritage gardens based on the spatial information extracted from historical boundary paintings. Some indicators, such as visual openness, connectivity and intelligibility, will be explored in the process to represent spatial patterns of heritage gardens. At the same time, aerial images of specific gardens will be captured from existing environment using UAV in accordance with the viewpoints in boundary paintings. These images will be compared with boundary paintings of the same garden to confirm spatial patterns and to detect changes. The outcome of this research will be a staged guide to decode boundary paintings and provide indicators for spatial pattern conservation in heritage gardens. This guide will be interested by landscape conservators, heritage planners and digital program developers.

**Key words:** heritage garden, boundary painting, 3D mapping, spatial pattern, 3D reconstruction

## 1. Introduction

The term heritage garden refers to a garden that is recognised as a place of historic and cultural significance. For example, the Summer Palace in China and the Palace of Versailles in France are typical heritage gardens in different cultural contexts. As a kind of cultural landscape, heritage gardens are the result of the accumulation of cultural values and attributes overlaying natural systems, in their tangible and intangible dimensions (Yang *et al.*2015). They constitute a key resource in enhancing community identity and fostering local economic development (UNESCO 2011). Today, urban sprawl and uncontrolled tourism development means heritage gardens are changing with increasing speed. Important historical information is being lost through destructive changes, and as a result, the cultural continuity of the past is challenged (Eetvelde and Antrop 2004).

Spatial patterns are the essential attribute of heritage gardens. A spatial pattern of a garden is a perceptual structure, placement, or arrangement of garden features. The essence of spatial pattern is the methodology used for spatial problems (Alexander 1977). Spatial patterns of heritage gardens contain not only historic values, but

also rich wisdom and knowledge of land use. It is therefore the key attribute in conservation practices. Spatial pattern of heritage landscape has been highlighted within many landscape convention programs, such as the Cultural Landscape Inventory in the U.S. National Park Service (1998), the Historic Landscape Characterisation programme in England (Aldred and Fairclough 2003; Clark *et al.* 2004) and the cultural landscape evaluation of the UNESCO World Heritage Convention (UNESCO 2009).

However, the lack of objective methods and reference to recognise and protect spatial patterns of heritage gardens has become a significant reason for the loss of historical information. In China, spatial patterns of heritage gardens are fading away as the result of landscape changes, and there is no reference to control changes in an acceptable way. Therefore, it is necessary to explore new resources and methods for spatial pattern protection.

Boundary painting, or jie hua, is a spatial style of painting in China, which is a valuable resource for spatial pattern recognition in heritage gardens. Boundary painting refers to the accurate depiction of architectural forms in a fineline style aided by the ruler (Britannica 2016). It was originally invented in the Jin Dynasty (265-

420 CE) to record architectural forms and became an independent style of painting in the Tang Dynasty (618-907 CE). However, the significance of boundary painting has not been realised, and boundary painting has not been fully decoded into applicable spatial references.

The development of 3D mapping technologies provides great potential on the decipherment of boundary paintings. Modelling the past and future of heritage landscapes and buildings to assess development impacts is one of the contemporary topics of digital heritage conservation (Short 2007; Vanegas *et al.* 2010). In China, boundary paintings have been explored mostly in qualitative ways. The artists, styles, painting techniques and historical contexts of boundary paintings are the main topics in exploration. There are rarely studies focusing on quantitatively translating boundary paintings to provide accurate references in conservation practices. Therefore, the overarching aim of this research is to explore an innovative approach combing boundary paintings and 3D mapping technologies to extract spatial information of heritage gardens. The objectives of this research are:

1. To identify the main features of heritage gardens through pattern analysis of boundary paintings.

2. To identify the main indicators of spatial pattern of heritage gardens in China based on 3D GIS.

3. To build a staged guide to extract spatial information from boundary painting of heritage gardens.

## 2. Project Proposal

### 2.1. A case study of Slender West Lake

This research will examine the case of Slender West Lake to demonstrate how to use 3D mapping technologies to extract spatial information from boundary paintings. Slender West Lake is located in Yangzhou City, Jiangsu Province, in east-central China (Fig. 1). It covers 12.23 square kilometres of protected areas. It was designed as a National-level Scenic and Historic Interest Area by the State Council of the People's Republic of China in 1988.

During the Qing dynasty (1645-1912 CE), Yangzhou was one of the most prosperous cities in the empire (Finnane 2004). Between 1775 and 1795, salt merchants, scholars and officials built a large number of gardens on the lakeside to please the visiting emperors and to cater for their own social and cultural practice. At the height of the Qing Dynasty, Emperors Kangxi and Qianlong visited Slender West Lake during their southern inspections. There were more than a hundred gardens and public buildings along the three-kilometre water course. In this period, court painters visited Yangzhou with emperors to record gardens in Slender West Lake for documentary purpose, which provide valuable information for conservation research today.

### 2.2. Data source, type and collection methods

Three types of data will be collected in this research. Firstly, boundary paintings of Slender West Lake in the Qing Dynasty will be collected as the major data (Table 1). Secondly, documentary evidence, including historic maps, local historic chronicles of Yangzhou and Slender West Lake will be collected as complementary dataset (Table 1). These two datasets will be collected from local management authorities, libraries, and museums and the Department of Archive in Yangzhou. Thirdly, existing condition of Slender West Lake will be examined through site observations. Spatial features will be recorded by hand-drawing maps, photograph and laser scanning devices. These datasets will be integrated into a GIS database for later analysis.

**Table 1** Boundary paintings and documentary evidence of Slender West Lake

| Sources | Documents |
|---|---|
| Local chronicles | The Eminent Sites of Pingshan, 1742 |
| | The Imperial Grace of the southern Tours, 1771 |
| | Chronicle of the Painted Barques of Yangzhou, 1795 |
| | Illustrations of the famous Sites of Yangzhou, 1822 |
| Artworks | Atlas of Great Landscapes of the Gardens in the South of Yangtze River, 1760 |
| | Illustrated Gazetteer of Pingshan Hall, 1765 |
| Master plans | Master Plan of Slender West Lake Scenic and Historic Interest Area 2005 |
| Professional reports | Brief Report on the 1978 investigatory excavation of the ancient wall of Yangzhou, 1979 |
| | Archaeological Survey Report of the Historic City of Yangzhou, 1987-1998 |
| | Research on Cultural Landscape Value of Slender West Lake in Yangzhou, 2011 |
| Aerial photographs | Aerial Photo of Slender West Lake Scenic and Historic Interest Area, 2008 |
| Topographical maps | Archaeological Map of the Historic City of Yangzhou, 1973 |
| | Topographical Map of Slender West Lake Scenic and Historic Interest Area, 2005 |

## 3. Expected Outcomes

The expected outcome of this research will be a decoding guide including three stages: Firstly, garden features in boundary paintings will be identified and grouped into different categories (Fig. 2); Secondly, the scale of each garden feature will be identified through referring-on local architecture styles during the same period; thirdly, based on the spatial information extracted from boundary paintings, digital terrain models of heritage gardens will be built in an ESRI ArcScene 10.2.2 platform. Lastly, the virtual model will be analysed by spatial analysis tools in ArcGIS, which leads to a group of indicators and parameters on spatial patterns.

## Acknowledgements

**Figure 1:** View of Slender West Lake, 2009, photography by Mao, Yongkuan.



**Figure 2:** Feature analysis: (top) boundary painting of White Stupa area in Slender West Lake, Atlas of Great Landscapes of the Gardens in the South of the Yangtze River, 1760; (bottom) aerial image of White Stupa area in Slender West Lake, 2006, Mao.

# References

ALDRED, O., and FAIRCLOUGH, G., 2003. Historic Landscape Characterisation: Taking Stock of the Method. Taunton: English Heritage and Somerset County Council.

ALEXANDER, C., 1977. A Pattern Language: Oxford University Press.

BRITANNICA, E., 2016. Gongbi, Chinese painting Encyclopedia Britannica.

CLARK, J., DARLINGTON, J. and FAIRCLOUGH, G., 2004. Using Historic Landscape Characterisation, English Heritage's review of HLC Applications 2002-03. London: English Heritage & Lancashire County Council.

EETVELDE, V.V. and ANTROP, M., 2004. Analyzing structural and functional changes of traditional landscapes - two examples from Southern France. *Landscape and Urban Planning*, **67**(1-4), 79-95. doi:10.1016/s0169-2046(03)00030-6

FINNANE, A., 2004. Speaking of Yangzhou: A Chinese City, 1550-1850. Cambridge (Massachusetts) and London: Published by the Harvard University Asia Center. Distributed by Harvard University Press.

SHORT, M., 2007. Assessing the Impact of Proposals for Tall Buildings on the Built Heritage: England's Regional Cities in the 21st Century. *Progress in Planning*, **68**(3), 97-199.

UNESCO, 2009. World Heritage Cultural Landscapes: *A Handbook for Conservation and Management*. Paris, France: World Heritage Centre, United Nations Educational, Scientific and Cultural Organisation.

UNESCO, 2011. *Recommendation on the Historic Urban Landscape*. Retrieved from Paris, France.

VANEGAS, C. A., ALIAGA, D. G., WONKA, P., MÜLLER, P., WADDELL, P. and WATSON, B., 2010. *Modelling the Appearance and Behaviour of Urban Spaces*. Paper presented at the Computer Graphics Forum.

YANG, C., SIM, J. and LAWSON, G., 2015. Deciphering Historic Landscapes: A Case Study of Slender West Lake in Yangzhou, China. *Landscape Research*, **41**(1), 95-112. doi:10.1080/01426397.2015.1041468