

RE-RELIC/ YUANMINGYUAN: AN EFFECTIVE PRACTICE IN VIRTUAL RESTORATION AND VISUAL REPRESENTATION OF CULTURAL HERITAGE

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Abstract:

There are plenty of cultural heritages in China over the long-term history. Multiple informations in the heritages recorded various aspects of Chinese history and culture. While most heritages left only ruins or fragments because the timber structure are vulnerable. How to make the contemporary people to see the past glorious sceneries, and how to help people take interest in destroyed heritage, are the subjects we devoted to.

Based on a long-term research and application of information technology, we set up an Innovative open-source technology platform called RE-RELIC which combined information database with visualization scenes of Cultural heritages. The research team was formed by professionals from several research fields, such as architecture history, archaeology, cultural heritage conservation, landscape, virtual reality, and so on. Innovative research and carefully selected projects focus on conserving cultural heritage and advancing multidisciplinary research worldwide.

The project named Re-Yuanmingyuan was the first practical project in the RE-RELIC Platform. Yuanmingyuan was the most important summer palace in Qing Dynasty. It was called 'the Garden of all gardens' as it assembled all kinds of architecture and garden styles from around the empire. It was burned down in 1860 and became ruins until today. Whether to rebuild Yuanmingyuan is a nationwide heated debate for nearly 150 years. Unquestionable, our Virtual restoration plan provided a new philosophy on balancing the relationship between archaeological sites conservation and historical scenes reemerging.

Our daily works includes: accurately measuring and comprehensive information collecting, precisely studying and restoration designing, 3-D modeling, digital pictures and animations making, virtual scenes interactive querying and public feedbacks receiving. Some techniques such as 3D Laser Scanning, CRP (Close-Range Photogrammetry), NDT (Non Destructive Testing), 3S (GPS, GIS, RS) are greatly enhance the technicality and precision of the archaeological information documentation.

In the past 2 years, we have completed not only 80 historical scenes located in 26 historic sites over 7 periods, from 1740 to 2010, but also the primary edition of database and web site. Experiencer can visit the 4-dimensional buildings and gardens in free views and touch the history of Yuanmingyuan via internet. This platform has abstracted great attention. Both experts and public considered that this approach of heritage conservation and presentation was effective and practical.

In this paper, we would like to share our ideas and experiences with the symposium participants. We will give a summary introduction of the Re-Yuanmingyuan project, includes its work frame, workflow, research method and current achievements. Furthermore, we expect more and more people would join in our subsequent plan, focus on the other cultural heritages, such as prehistoric relic, ancient cities, intangible cultural heritage, and so on.

1. The particularity of the Yuanmingyuan Ruins

Yuanmingyuan, started to be built in 1707, the 46th year of the reign of Emperor Kangxi, who bestowed it on his fourth son Yinzhen. After Yinzhen acceded to the throne as Emperor Yongzheng in 1723, he expanded the original small garden into the 'imperial summer palace'. From then on, the successor emperor continues to use Yuanmingyuan as an imperial residence center equivalent the Forbidden City and live there permanently. This tradition was kept until 1860. As a result, for over 130 years during the reigns of five emperors - Yongzheng, Qianlong, Jiaqing, Daoguang, and Xianfeng - Yuanmingyuan had played an important role in national politics and be widely known as the Old Summer Palace.

Moreover, it epitomized the imperial garden art of the Qing Dynasty and was called 'the Garden of all gardens'. It assembled all kinds of architecture and garden styles from around the empire with more than 100 relatively isolation thematic subareas (scenic areas) distributed in the area over 350 hectares. In addition, some Western-style buildings which be called Xiyanglou, were built in its northeastern corner. (Figure 1) Unfortunately, the masterpiece was burned down by the Anglo-French Allied Forces in 1860 and just few masonry relics surviving. So, could you imagine its past glorious sceneries from the ruins? (Figure 2)

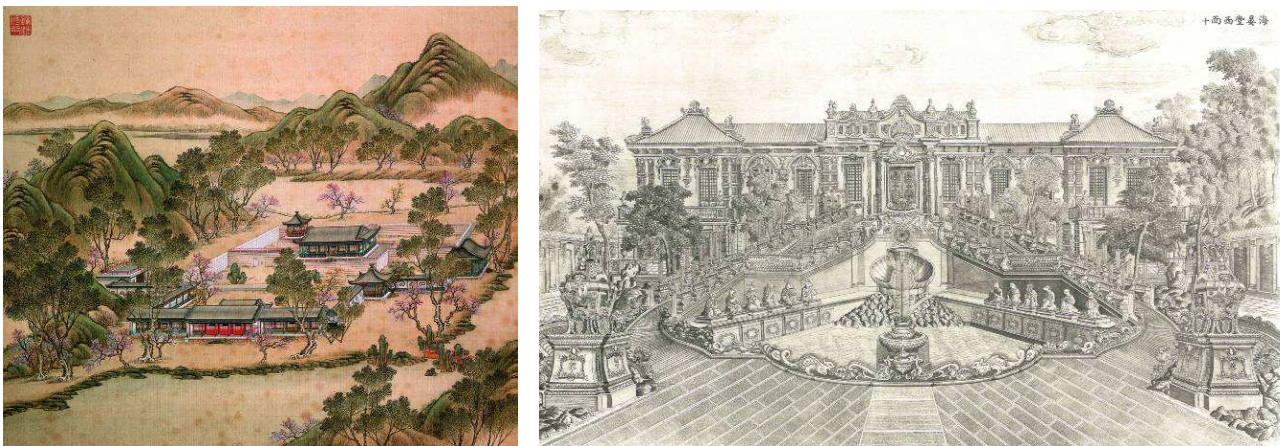


Figure 1: The realistic pictures of Yuanmingyuan in Qing Dynasty
(Left: Chinese traditional scenic area 'Tantan dangdang', ink and pigment on silk, 1744;
right: Western-style scenic area 'Haiyantang', copperplate etching, 1786)



Figure 2: The Ruins of Yuanmingyuan in 2010(the same site as above)

After Yuanmingyuan was destroyed, almost every Chinese people want to reappear with its beauty. While, as we know, any form of restoration in the archaeological sites should be very caution. Thus, whether to rebuild Yuanmingyuan is a nationwide heated debate last for nearly 150 years.

Obviously, we need a new way to coordinate the current Yuanmingyuan Ruins conservation with the public desire of its historical scenes reemerging.

2. Framework of the RE-Yuanmingyuan Project

Re-Yuanmingyuan was the first practiced project in the RE-RELIC Platform. On purpose of advancing multidisciplinary research, sites conservation and daily management, multiple presentation and widely public participation of the Yuanmingyuan, the project contains three tasks:

- 1) Establishing the comprehensive basic information database which integrated with convenient retrieving function to advance the study of Yuanmingyuan.
- 2) Creating the infallible four-dimensional simulation models based on in-depth academic research to visualize the vicissitudes history of Yuanmingyuan.
- 3) Building the interactive platform with public participation to promote the social support for the conservation of the Yuanmingyuan Ruins.

The research team was formed by professionals from several research fields, such as architecture history, archaeology, cultural heritage conservation, landscape, virtual reality, and so on. Our daily works includes: accurately measuring and comprehensive information collecting, precisely studying and restoration designing, 3-D modeling, digital pictures and animations making, virtual scenes interactive querying and public feedbacks receiving.

3. Worldwide comprehensive information collection and database application

The current efforts to collect information fall into two major categories: historical archives digitization and the first-hand relics spatial data capture.

3.1 Historical archives collection and digitization

Historical data is the most important basis for Yuanmingyuan history research. As an imperial garden, Yuanmingyuan left plenty of historical records, but most of these are scattered among vast volumes of documents and archives, which are scattered even farther apart all over the world.

Since 2000, we have sought and acquired the high-precision electronic version of more than 2,000 original historical archives related to Yuanmingyuan, such as the original design drawings, realistic pictures, old photos, and building regulations, at following domestic and foreign collections: the Tsinghua University, the Palace Museum, the National Library of China, and the National Library of France, Museum Guimet, Fontainebleau Museum, the Library of Congress. Furthermore, we have collected all archeological reports, photos, topographic maps, and over 100 volumes of documents and monographs, and several hundred research papers on the subject since the early 20th century.

Based on these data, we generated full-text digitization files identical in format to the original historical documents, for example, the emperors' poems, the construction project settlement report and memorials to the throne, enabling quick and accurate full-text search, which greatly facilitates researchers.

3.2 The first-hand relics spatial data capture

Though the main buildings of the garden have been burned down, the unearthed foundations and scattered broken pieces are highly informative, reflecting how unique and exquisite the garden used to be. Their importance is self-evident. However, because of various challenges against the open-air preservation of the ruins, the sites were soon re-filled or hurried restored. Thus researchers and common visitors can't experience the impressive view of the sites, and the rich information is yet again concealed.

In view of this, the field surveying, recording, and accurately measuring of the Yuanmingyuan Ruins become an essential work. Some techniques such as 3D Laser Scanning, CRP (Close-Range Photogrammetry), NDT (Non Destructive Testing), 3S (GPS, GIS, RS) are greatly enhance the technicality and precision of the relics data capture. Meanwhile, traditional manual measurement, photography and videotaping are used to number and map the sites and scattered components in detail, damage survey and assessment, and establish detailed follow-up archives of diagrams and texts.

Furthermore, the precisely spatial data have greatly improved the efficiency and accuracy of virtual reassemble. For example, the Bilan-Bridge (a stone arched bridge located to the north of 'Tantandangdang') had collapsed into many pieces. We completed a precise measure of the every scattered piece by means of 3D laser scan, and input the data into AutoCAD to generate the exact spatial models, which be trial reassembled in many possible ways to find their infallible location. Base on these efforts, we find out the exact form of the bridge and replicated its intricate engraved decorations. (Figure 3)



Figure 3: 3D Laser Scan and virtual reassemble of the Bilan-Bridge
 (1. 3D Laser Scan at the sites; 2. Primitive spatial models; 3. Processed models of the bridge railing;
 4. bridge railings were virtual reassembled in infallible location)

3.3 Data Storage And Retrieval System(DASTAR)

To facilitate the integrated storage and retrieval of vast data from multiple sources, and provide a more visualized time-space framework for researchers, managements and general public, we developed a spatial database based on 4-D GIS. Using 3-D engine as well as technology of huge data processing and space orientation, the digital informations - including historical archives, archeological report, restoration design drawings, sites photos and monitoring data - are attached to precise detailed 3-D models of the current sites and their historical appearance during different periods. (Figure 4)

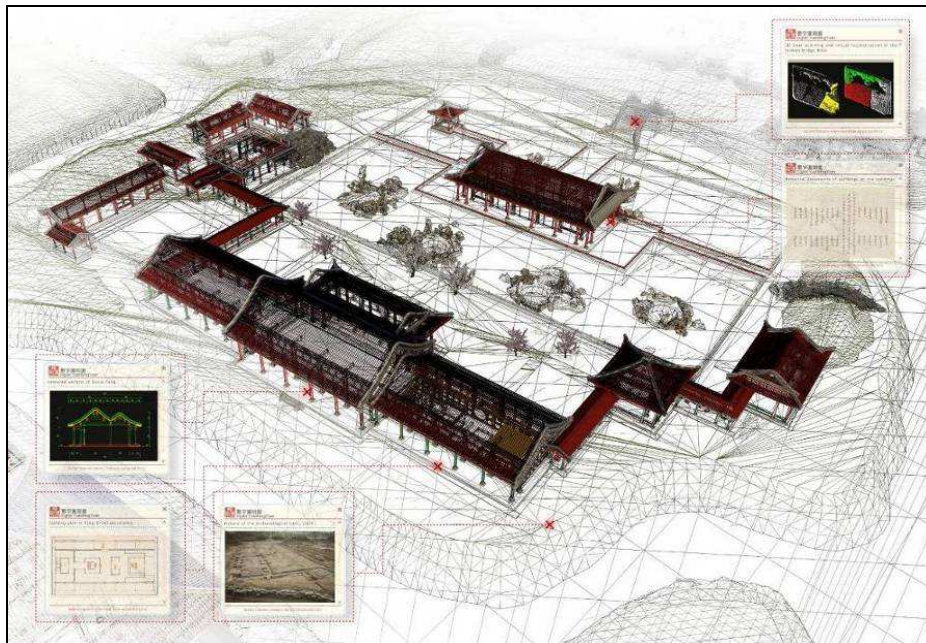


Figure 4: Concept diagram of the Database

Three phases are recognizable in the storage and retrieval process: data input and validation, data storage and data retrieval. On the basis of the characteristics of the Yuanmingyuan archives, 9 categories and 31 sub-categories with different property information for each, and a step by step validation system (input, first review, second review) have been set up to ensure the reliability of every uploaded file. The database supports the uploading of data in various formats - CAD, JPG, PDF, 3DS, DOC, AVI, etc. The validation data were linked to the virtual time-space, which were management at four spatial scales (garden, subareas, buildings, and components) on the time sequence, and authorized different classification levels to meet data

providers' need for confidentiality. Options provided include common search, advanced search, full-text search, and spatial search, which enable the comprehensive retrieval in the multiple information resources - texts, drawings, photos, videos, and virtual space. Besides, some common system management functions, such as data backup and recovery, log management, are included.

4. Virtual restoration and visual representation

Historical archives reveal the boundaries of Yuanmingyuan changed several times with yearly construction and frequent reconstruction, such as fundamental changes took place in 'Xinghua-chunguan', 'Shangxia-tianguang' underwent major reconstruction several times, and other scenic areas experienced numerous small-scale reconstructions. Furthermore, the nature of traditional Chinese timberwork demanded regular renovations, such as the repair of the roof, the replacement of wooden components, the renovation of painted decorations, or pasting them up with new paper. That means, the garden actually kept evolving and its appearance kept changing during the 150-odd years from 1707 to 1860.

Additionally, because classical Chinese gardens are designed to offer a fluid spatial experience, in which different vistas are revealed to the visitor when he walks from one place to another. Take 'Huifang-shuyuan' for example: people could not really understand the artists' conception ('Why is the pond so limpid? / Because it's fed by flowing water' [two famous lines by Zhu Xi, a Confucian scholar of the Song Dynasty]) unless they start from Wenjin (lit. 'inquiry about the ford') and wind their ways through the cave in the rockery, at the end of which a broad view is suddenly revealed.

Therefore, to give the virtual reality experience of the garden's continuous evolution history, a four-dimensional time-space framework was established in the virtual restoration study in order to display all the important changes happen in every subarea, instead limited to some buildings or a certain perspective as the movies used to be. Based on the available historical data, we have divided the garden into 100 spatial units (scenic areas), as well as divided its 3-century evolution history into 13 phases. Until now, we have completed 80 historical scenes located in 26 subareas over 7 periods - the early Qianlong period, the mid Qianlong period, the Jiaqing period, the early Daoguang period, the later Daoguang period, the Xianfeng period, and the archeological sites period, which present how captivating the Yuanmingyuan used to be.

First of all, we reproduced an accurate digital model of the archeological sites according the detailed measurements and photos of the excavated sites, to give a full representation of all relics' data and provide researchers with precious on-site information, as well as offer a utility method for the conservation and the daily management of the Yuanmingyuan Ruins in the near future. After that, we reconstructed the historical scenes during different phases based on in-depth academic research, which can shed light on each emperor's peculiar interests. In addition, our study also penetrates into the interior space of buildings, in which the emperors lived and historical events happened, reflecting the truthful life and multi-level history. (Figure5-10)



Figure 5: The digital scene compared with the photo of 'Tantan-dangdang'(A: digital scene; B: photo)



Figure 6: The virtual restoration scenes compared with the sites scene of 'Tantan-dangdang' (A: in the early Daoguang Period; B: archeological sites)



Figure 7: The virtual early scenes compared with the later scenes of ‘Xinghua-chunguan’



Figure 8: Virtual panoramic aerial view of ‘Jiuzhou’ area in the mid 18th century (the early Qianlong Period)



Figure 9: Virtual view of ‘Fanghu-shengjing’ in the late 18th century (the mid Qianlong Period)

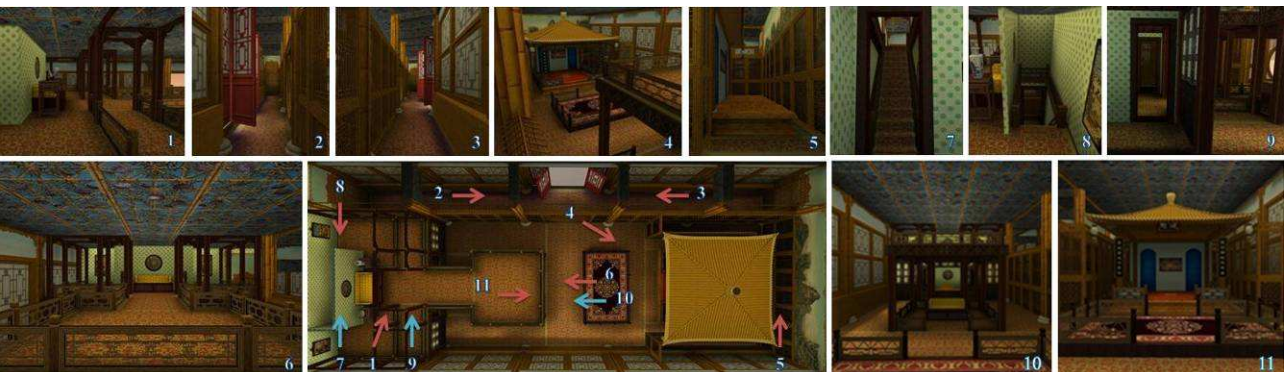


Figure 10: Virtual interior space of ‘Banmuyuan’ in the late 18th century (the mid Qianlong Period)

In order to ensure the digital restoration scenes achieve a closer resemblance to its original appearance and reflect the authenticity and uniqueness of Yuanmingyuan, the visualization work are divided into four major steps - basic information unscramble, restoration design, digital scenes making, and continuously updating.

- 1) Basic information unscramble: this is done by the scrutiny and perennial comparing analysis of the historical documents, original design drawings, the old realistic pictures and photos, the archeological reports, the detailed survey of surviving sites and relics, and contemporary conventional architecture, as well as reference to similar buildings, interior decorations and furnishings.
- 2) Restoration design: In each scenic area restoration design, the researchers need to complete the design drawings consists of the following: the general plans, the plans, elevations and sections of individual buildings, the landscape and vegetation arrangement plan, the detail drawing of the painted decorations, interior decoration, and plaques and couplets. These drawings would be submitted to the first-stage reviewers for confirmation or revision and then to the modeling producers.
- 3) Digital scenes making: The 3-D models comprise models of the sites, restoration models of buildings and landscape. The models were modeling complied with the restoration design drawings. The textures are obtained through real photos or customized according to the archival records. The produced digital scenes are submitted to the second-stage reviewers for examining the precision of the models as well as checking the spatial appearance through the 3-D space.
- 4) Continuously updating: After modification, the semi-finished digital scenes are released on the Internet to solicit feedback from researchers and people from all walks of life, and then modified according to the collected relevant advice and clues. This is a fully open step, which will be followed up permanently.

During the restoration design, we refrained from a simple imitation of the customary architectures of Qing Dynasty. Instead, we confirmed a series of special rules on the design of all details of the buildings as well as the pattern of the courtyards, the rocks, the vegetation, and the delicate decorations, base on the diversiform sorted out credible materials.

For example, in the restore design of Qinzheng Hall in the mid Daoguang Period: the primary form and dimensions of the building, and the length, diameter and color of the columns were designed in terms of the text noted in the original design drawing (No.002-2) which was paint in 1837 by the royal architect. The painted patterns of the beams were designed according to the description in the Design Rules of Yuanmingyuan (*Yuan Ming Yuan Nei Gong Ze Li*). The diameter and pattern of the Pantile were determined by the measurements of the remains. The pediment were designed refer to the cotemporaneous building surviving in other imperial gardens. It should be note that, its asymmetric roof and uncustomary slenderness ratio of column which far exceeds the customary ratio 10:1 and comes to 13.68:1, showing the creativity and uniqueness in construction technology and decorative style, as well as the different characteristics and fashions of the early, mid or late Qing Dynasty. (Figure 11)



Figure 11: Restoration design drawing and model with credible materials of the Qinzheng Hall

To ensure the academic rigor of the virtual scenes, and to leave detailed records for subsequent modification and improvement, we marked the each models with accuracy grade according to how detailed and sufficient data are on which the design is based. At the present stage, the accuracy of the finished buildings is mostly

between 50% and 85%. An accuracy of 90% has been achieved for Guangfeng-jiyue Hall at ‘Tantan-dangdang’ thanks to the well-preserved sites, the detailed archives; an accuracy of 95% can be achieved for the Goldfish-Pond and Bilan-Bridge at the same sites because nearly all components have survived.

After the practice in the first phase, we have become more keenly aware that the Re-yuanmingyuan Project Will be a complicated and lasting mission. Judging from the currently available data, by the end of 2012, we will have completed the digital restoration of another 10 scenic areas, located in the periphery of Jiuzhou Qingyan and the shore of Fuhai Lake, and fully started the precise data capture of the Xiyanglou ruins. The start of the digital restoration of the other scenic areas will have to await the progress of archeological excavation and the further publication of archival documents. An optimistic estimation is that the consummate scene of the entire garden will be completed in 2020.

5. The interactive platform with public

We kept in close touch with the public by means of the thematic portal site (www.re-relic.com). In the website, we organize a number of columns and various types of virtual display, including 360-degree panorama browse, specified path browsing, computer-generated animation and images based on the virtual reality scenes, along with the brief description of the Yuanmingyuan, digital archives and research papers comes from the database, and the concept of digitized conservation, which enable visitors to view Yuanmingyuan's magnificent and vicissitudes across time and space. In addition, they could join on-line interactions based on the virtual space, such as the release of information, interactive querying, real-time discussion, and the uploading of information. In this way, the website becomes more interactive and interesting, attract more public attention, and receive continuously feedbacks, such as research clues, suggestions on conservation, and so on.

Additionally, we have hosted International Symposium and Fan Meeting to promote the face to face contact. Experiencer can visit the Yuanmingyuan in free views and touch its dynamic history via keyboard, and participate in our works. Both experts and public considered that this approach of heritage conservation and presentation was effective and practical. (Figure 12) Furthermore, we are attempting to set up small display terminals, Application clients, or special digital experience rooms at such places as the management of cultural heritage, cooperative museums, archives and research institutions, where accurate, interesting, educational and up-to-date informations are easily conveyed to the public by means of animated cartoons and circular-screen, 3-D or 4-D movies.



Figure 12: Photos of the activities (left: VR experience; mid: Modeling experience, right: interlocution)

6. Conclusion and prospect

Base on these efforts, the RE-RELIC Platform has abstracted great attention and provided a new philosophy on conservation and presentation of the cultural heritage. It has been approved as an appropriate way to promote public support for the conservation of cultural heritage, increase social and economic benefits without affecting the property itself, and alleviate contradictions between cultural heritage conservation and urban development. This may also bring about an all-round public participation by motivating the public to collect the historical archives, research progress and conservation fund.

Our subsequent plan will extend to the other Unique Historical Treasures, such as prehistoric relic, ancient cities, intangible cultural heritage, and so on. Some representative projects, for instance the Re-Luoyang City Project and the RE-Daheacun Project, are ongoing. Furthermore, we will attempt to further explore the integrated and in-depth application of the accurate measurement techniques and the BIM (Building Information Model) to the full 4-D research process, so as to enhance the research platform's capacity for data capturing and integrated management. Sincerely, we hope and welcome more and more scholars and professionals to join in us.