Multisource Spatial Data Acquisition and 3D Modeling of Cultural Sites

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Objective-oriented 3D technical requirement

3D data acquisition and modeling for different type of sites

The System Development of Multi-Source Data Management and 3D Display for cultural sites

The Brief Introduction to the Shuanghuaishu Site
Object 1: The capital site in Shang Dynasty (3600BP)
Object 2: The Hangu Pass World Heritage Site (2000BP)
Object 3: The Xinzheng Gate site of the Capital in Song Dynasty (1000BP)

The field site this afternoon: The Shuanghuaishu archaeological site (5300BP)
Object-oriented Sites 3D technical requirement

※ The research and protection of cultural sites demand for 3D spatial technology

3D Lidar Scanning------------------ Multi-view photography-------- UAV photography

◆ Preserve of the sites information
◆ Virtual restoration
◆ Deformation monitoring of cultural relics
◆ Cultural sites measuring and modeling
◆ Surveying and mapping for the protection of grotto and stone sites
◆ Protection and restoration of museum collections
◆ Protection of large cultural relics
◆ Calculation of cultural relics volume
◆ Measurement of archaeological sites

◆ 3D reconstruction of vestiges and remains
◆ 3D reconstruction of archaeological sites

◆ Probe into cultural sites
◆ Archaeological record and surveying and mapping
◆ Cultural sites monitoring
◆ 3D modeling of cultural sites

Agisoft photoscan
Object-oriented Sites 3D technical requirement

UAV photography and 3D modeling

High efficiency, suitable for large-scale

Multi-angle photography 3D modeling

High efficiency, rapidity, low precision

Multisource data and model

Multisource data management and display system

The HanGU Pass world Heritage

Ground lidar scanning and 3D modeling

High precision Post-processing with heavy workload

The Ground wall Site

Traditional surveying and mapping DLG Plan, Profile map and disease information extraction

Site objects (Research protection requirement of type, characteristic, etc.)

Relic extraction, archaeology mapping

The Xinzeng Gate site

Relic Document, Plan, Profile map, Video Data, etc.

The Xinzheng Gate site

Multi-angle photography 3D modeling

Multi-source data management and display system

Object-oriented Sites 3D technical requirement

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Multi-angle photography 3D modeling

Multi-source data management and display system

Object-oriented Sites 3D technical requirement
Object 1: The capital site in Shang Dynasty (3600BP)

**Features:** The ground wall located in built-up area;

**Requirements:** the surveying and mapping data of the wall and its environment on both sides; 
The 3D model of the city wall and subtle disease observation; 
Meet the needs of basic data, model, and map that are linked to the improvement of the wall’s surrounding environment and the wall’s repair.

**Appropriate technology:** Using the traditional way of surveying and mapping to build a unified coordinate system and acquire environment information in the site; Using the ground-based 3D ladar canner to capture the wall’s information.

**Key points:** record and survey of environment features along the wall; 
All-round fine 3D scanning of the wall; 
Disease parse and accurate observation in detail.
Object-oriented 3D technical requirement for sites
——Xinzheng Gate Archeological Site

Object 2: the archaeological excavation of the city gate in Song Dynasty (1000BP)

Requirements:
- Refined records of natural accumulation and trace
- Precise 3D information of different historical age Stratum
- 3D model of different historical age Stratum
- Relics feature extraction and mapping
- Virtual reappearance of topical historical age
- Application of future archaeology park construction

Appropriate technology: Using Lidar Scanner in layered scanning to collect refined 3D information of different historical stratification in archaeological excavation. Using multi-view photography method to collect image sequence information of topical historical stratification in archaeological excavation.

Key points: Holographic record of different historical stratification information, Relics remains, characteristic information extraction and mapping.
Object-oriented 3D technical requirement

Object 3: the World Heritage HanGu Pass in Han Dynasty (2000BP)

Features: The ancient pass and city gate
          The valley environment

Requirements:
The Gate and its surrounding geographical environment
The Gate 3D model
Meeting the requirements of HanGu Gate site’s surrounding environment management and demand of site repairing design.

Appropriate technology: Using Lidar scanner and UAV photography to collect 3D information of HanGu Gate. Laser scanner can collect The HanGu Gate’s high precision 3D information. UAV photography can capture the image information of The HanGu Gate’s core zone. Construction hierarchical fidelity model of relic core zone and main building.

Key points:
The document of site’s surrounding environmental elements, 3D modeling integrally;
Comprehensively refined 3D scanning and modeling for The Gate; Two models precisely matching.
※ 3D data acquisition and modeling for different type of sites

The city wall site in Shang Dynasty (3000BP)

Control points

Scanning sites
Spatial information acquisition of The City Wall Site

- 200,000 m² topographic map of The city wall;
- 55,000 m² 3D ladar point cloud of city wall site;
- Acquire 612 texture information of the city wall body.

※ 3D data acquisition and modeling for different type of sites
3D data acquisition and modeling for different type of sites

The city wall site in Shang Dynasty (3000BP)

- Modeling of The City Ground Wall Site

**Selection of city wall point cloud filtering algorithm**

- Automatic removal of vegetation algorithm
  — aim at gentle slope surface and plane

- Redundant point cloud filtering algorithm
  — aim at steep slope

- Surface approximation method
  — aim at the rough surface

Point cloud filtering – remove the redundancy and attachments to the point cloud
3D data acquisition and modeling for different type of sites

The city wall site in Shang Dynasty (3000BP)

- Modeling of The Ground Wall Site
* 3D data acquisition and modeling for different type of sites

The city wall site in Shang Dynasty (3000BP)

- Extraction of relics feature information based on model

Plane contour map based on 3D model
3D data acquisition and modeling for different type of sites

The city wall site in Shang Dynasty (3000BP)

- Modeling of the ground wall relic during Shang and extraction of relic information

Elevation based on 3D model

- Texture mapping
- Construction of perpendicular reference plane
- In scale city wall elevation projection
Cross-section diagram based on 3D model

Make cross section diagram based on superposition of section line and model
3D data acquisition and modeling for different type of sites

The city wall site in Shang Dynasty (3000BP)

- Modeling of the city wall relic during Shang and extraction of relic information

Disease information (gullies, path, collapse, etc) parsing and accurate extraction based on 3D model
3D data acquisition and modeling for different type of sites

—— the HanGu Pass in Han Dynasty (2000BP)

Acquiring 11 sites’ point cloud data and 99 texture images about the Gate; 341 UAV images of core relic zone about 0.4km² during 5 times flight missions.
3D data acquisition and modeling for different type of sites

——— the HanGu Pass in Han Dynasty (2000BP)

3D model of the gate, using the method of triangular patch and surface modeling based on point cloud of ground Ladar.
Color 3D model, high resolution DEM and DOM by the reconstruction method of 3D multi-view based on UAV images.
The above results respectively satisfy the needs of heritage area restoration and protection planning, providing basal data and information for heritage management and protection.
Excavation Scope of XinZheng Gate Relic

Plan Area: 16000 m², No.1 phase: 2000 m²
3D data acquisition and modeling for different type of sites

---Xinzheng Gate Archeological Site

3D information extraction of the site excavation scene

Completed 3D and texture data collection for 33 times as a total of 391 sites and 3519 images. The raw data volume is 70GB, and 420 GB after being converted to processing format. 334 images of multi-view in two typical periods collection has also been completed.

Acquisition station of 3D point cloud

3D Scanning Point Cloud

3D Color Point Cloud

Qing Dynasty Stratum Multi-view

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3D data acquisition and modeling for different type of sites

——Xinzheng Gate Archeological Site

Build 3D models of the layer

Building refined DEM, DSM and other 3D models of different stages stratum, as the base of sites environment and landscape reconstruction.

- Morden Stratum
- Early Morden stratum
- Silting Stratum 1
- Silting Stratum 2
- Qing Dynasty Stratum
- Qing and Jin Dynasty Stratum
Qing Dynasty Remains DEM Constructed by Lidar Point Cloud Data

(Area: 2000㎡)

Build 3D models of the layer

※ 3D data acquisition and modeling for different type of sites

——Xinzheng Gate Archeological Site

地表下，揭开后，清代的村落遗迹：7米多的大路，清晰的车辙痕迹，路边的沟渠，渠边的马蹄印，通往院落和大路的小路，小路边的水井，水井中散落的乾隆币、烟袋锅、陶罐与青瓷片，院落不远处一垄垄的菜地，裹在冲积层中的木箱，挡住木箱的残树。
The method of constructing triangular patch and surfaces model based on 3D laser point cloud in a layered and blocked strategy has completed high precision 3D model of different historical period stratum of XinZheng Gate Phase No.1 during archaeological excavation.

The color 3D models of archaeological excavation stratum of two typical historical period are reconstructed by multi-view 3D image.

Key point: fine zoning modeling of object-oriented relics features.

Layered 3D model based on 3D Lidar point cloud has the advantages, such as: high accuracy, scalability, characteristic relics information acquisition and archaeological digital mapping. But its disadvantages are heavy workload of data processing and complicated process.

3D model based on multi-view image though has relatively low model accuracy. But the color 3D model constructed by this way has direct-viewing characteristic and high modeling efficiency.
3D data acquisition and modeling for different type of sites

——Xinzheng Gate Archeological Site

Feature extraction and mapping based on 3D model

Providing the method of features extraction based on 3D relics model. Achieving high accuracy, digitizing method of relics figure, profile map and relics unit map.
The Spatio-temporal Data Management System have integrated management method to relics multi-source heterogeneous data. This system is used to achieve relics spatio-temporal data (including: original documents, analytical and statistical data, video data, 2-3D maps, 3D laser point cloud, UAV image data, plane and spherical panorama etc.) import, delete, browse, disposal, Construction of data association, so as to realize multi-source heterogeneous data management.
3D Culture Relics Virtual System is used to achieve category display of relics multi-source heterogeneous data, relics information analyst, inquiry and statistic, relics data backup, etc. This system can display documentations, video materials and relics spatial informations by 2D, 3D, panorama mode.
Relics Import

CAD Data Import

2D Map Arrangement

PPT Document Editing and Presentation

Word Document Editing and Presentation

Video Document Presentation

Photograph Data Display

Data Query and Display

Archaeological Stratum
The System of Multi-Source Data Management and 3D Display for Cultural Sites

- 2D Map
- Color Point Cloud
- Plane Panorama of One Site
- Spherical Panorama of One Site
- 3D Archaeological Stratum Model
- Qing Dynasty Stratum Surface Model
Field survey this afternoon: Shuanghuaishu Site

Locate On the loess plateau near the Yellow River and Yiluo River

Shuanghuaishu site is located on a mound of Heluo town of Gongyi city, where is 2km to the south bank of Yellow River and 4km to the east bank of Yiluo River.
Settlement site with three circle trenches (inner, middle, and external).

Because of the research: seeking for the origin of China silk—the question about Cultural appearance and the origin of civilization of Yangshao period in Zhengzhou area, the initiative excavation of Shuanghuaishu site officially begin.

According to the result of prospection, the remain area has reached 1.17 million square meters, and it is a middle and advanced stage of Yanshao period (5300BP). For now, this site has excavated 3000 square meters. The important discovery has trebling large circle trenches, a big rammed earth relic, two tombs of Yangshao period, a distribution area of large house, and 13 sacrificial pits with plentiful or special antiques.
The plan of digital environmental archaeology for the Shuanghuaishu Site from 2018 to 2020

① **3D data acquisition and modeling** for the site and its environment.

② the environmental archaeology of the Site through morphological analysis, sporopollen analysis, dating, sedimentation analysis, and so on.

③ Key point is the location of the Yellow River 5000 years BP.

④ Virtual reality of the settlement and its environment.
Thanks

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